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Real-Time Management Control in a Large Scale Man-Machine System[1]

by **D. G. MALCOLM**

Director, Operations and Management Research, System Development Corporation

MANY writers have described the era of "information technology" our society is now entering as one wherein the capability to formulate decision criteria precisely and to process information electronically will create markedly new patterns in management. Prognostications include a trend toward recentralization of many management functions, toward semi-automated management and toward an organizational philosophy formed around the precise information and communication needs of the activity.

This chapter explores how far we have come in learning to "design" optimum management controls, and presents the thesis that the prototypes of integrated and automated management functions are perhaps first being experienced in the current development of such real-time military control systems as SAGE and SACCS. A study of approaches and solutions to the design problems of these military systems offers some valuable parallels to the design problems in business management controls. In the following pages, some of the problems that faced the designers of the SAGE system will be examined, along with some of the solutions now embodied in the system. Finally, a plan to bring experience in military control systems to bear on research at SDC in business management control systems will be discussed.

However, before turning to this task, it is necessary to establish some points of reference in regard to current uses of electronic computers in the management domain.

USES OF ELECTRONIC COMPUTERS

In the rush to apply computers to the automation of existing information systems, the task of redesigning a given system so as to be consistent with an integrated total company information-communication need is generally not undertaken. Rather, an application is made in one component of the organization with little more attention given to the total company system than beyond a compatibility check. While this approach may be justified on grounds that improvements of this size and scope must start modestly and build gradually and surely, there is a growing recognition of some of the suboptimal results that can occur. Thus, electronic computers are not being used in ways that tap even one-tenth of their ultimate potential in the management process—particularly in industry. The situation will become a matter of greater concern to the users of computers as the nature of this potential and the means of achieving it become better recognized. In short, the situation will appear to get worse before effective long range programs are designed and under way.

An examination of the four major uses of computers in the management process will help to elaborate on the foregoing statement.

The major uses of computers are:

1. As *a data-processing tool* in the automation of the information, communication, reporting and control systems.
2. As *a design tool* in problem solving in the research and design of management control systems, in policy determination, and in planning studies.
3. As *a training tool* in presenting training exercises.
4. As *a controlling device*, in decision making—an "on-line" controlling device.

For the purpose of this discussion, a management control system is defined as a set of policies, procedures, and information processing, which is designed to give direction to activities by clearly establishing goals, by measuring progress toward these goals and by indicating or initiating corrective action. Over the years, management has developed several approaches for providing control. Typical methods have included organization, planning, scheduling, inventory, quality, cost and manpower controls. It is significant to note that each of these is a component or function of the establishment and that the concept of integrated total system control still remains virtually unexploited.

A DATA-PROCESSING TOOL

Since the first installation of a large scale electronic computer strictly for business use in 1954, at General Electric in Louisville, there has been a mushroom-like growth in the application of computers to the routine automation of existing information, communication, personnel and data reporting systems, such as payroll, inventory position and control, production release and invoicing systems. Of the over 650 million dollars of com-

[1] Based upon a presentation to the Management Control Systems Symposium, July 28-31, 1959, System Development Corporation, Santa Monica, California. (To be published by John Wiley and Sons, Inc., as a chapter of a book on management control systems.)

puters installed by mid-1959 and the 600 million dollars worth of equipment on order, it has been estimated that up to 90 percent of machine time will be used for applications in these areas.

It should be pointed out that most of the systems being automated are not evaluated for the purpose of determining whether or not they best perform the function for which they were initially designed. The majority of such computer installations are undertaken for the purpose of reducing time in report preparation or in an attempt to effect clerical savings.

A DESIGN TOOL

The computer is being used increasingly as the vehicle for research in the design of management control systems and for policy determination. Another important use is in operations research studies where complex analyses can only be performed efficiently and in a timely manner on the computer. These studies can, therefore, be categorized into two broad approaches—complete analytical formulation of a complex problem, and computer simulations to solve problems experimentally.

Analytical formulations of problems using approaches such as linear programming have in many cases been built into the on-going control of operations. In a like manner, the simulation approach has been useful as indicated by the considerable number of projects undertaken in systems design and evaluation, systems research, and planning and training (4). The use of analyses of this type will be necessary for on-line management controls to provide the predictive capabilities desired by management.

A TRAINING TOOL

There is a growing utilization of computers in the area of education and training. Simulation exercises are proving to be a most effective way of posing realistic, fast reacting system problems to business students, managers and executives. The "automated case history" approach provides the immediacy and realism needed to obtain real involvement and motivation on the part of the trainee. It is evident that system training in large, new systems will necessitate appropriate computer simulation training exercises in order to assure effective introduction of these systems.

A CONTROLLING DEVICE

At present, only exploratory work is under way in using the computer directly in management decision making. In this category of usage the computer may be viewed as an "on-line" or "in-line" controller—operating on the information received concerning sales, production, changes in environment, etc., to make decisions on personnel requirements, schedules for production, inventory pricing, etc., on an up-to-date basis. Such usage, to be effective, involves having adequate decision-making criteria in a computer model of the company. The challenge facing the would-be designer of a truly integrated on-line control system is:

1. To utilize the computer and associated input-output equipment as an on-line device.
2. To make the computer an effective instrument for experimenting with and evaluating the effectiveness of proposed changes in policies, procedures and plans.

The only significant strides currently being made are in some of the components and functions of the business.

REAL-TIME CONTROL, REAL-TIME COMMUNICATION AND REAL-TIME INFORMATION SYSTEMS

In using a computer as an integral on-line controlling device, the "real-time control, communication and information system" has evolved as a system design concept. By this is meant that the information is transmitted instantaneously, without conversion, into a centralized computer which processes it, compares it with predetermined decision criteria and issues instructions to men and/or machines for corrective or purposeful action. This may be thought of as "real-time control." Further, the computer by means of direct outputs informs affected parties of this information as it is developed. This is "real-time communication." Lastly, suitable condensations of the above information are prepared, transmitted and displayed to higher levels of management for broader system decisions. This is "real-time management information."

The meaning of the word "real-time" lies in the fact that information is used as it develops and that elements in the system are controlled by the processed information immediately, not after the fact or by making periodic forecasts of the expected future state of the system. The best known examples of systems of this type are currently to be found in the military. It is in these applications that we may find some guidance in the way of design approaches that may be useful in evolving better on-line management control systems.

MILITARY OPERATING AND COMMAND CONTROL SYSTEMS

In recent years the application of electronic computers to military operating and command control systems has proceeded at an increasing rate. In the Air Force these are referred to as electronic support systems. As an indication of the extent of interest in such systems, the Air Force is currently spending more than a billion dollars per year on them. However, this expenditure includes equipment in addition to the computers. In many of these systems, the computer complex is the central nervous system which processes, integrates and analyzes the various information inputs, makes and communicates appropriate decisions, and develops the display information required by the ultimate human decision makers. A few examples of such centralized, real-time, computer-controlled systems are:

1. SACCS (Strategic Air Command Control System)—a system which is designed to keep the SAC Commander continuously posted on the up-to-the-minute status of every SAC bomber and missile. There are several echelons of management control to be tied together in this system, involving a network of computers for information and control purposes.
2. SAGE (Semi-Automatic Ground Environment)—a continental air command and warning system. SAGE is a system designed to maintain a complete, up-to-date picture of the air and ground situation in the Continental United States and other parts of North America, to control modern air defense weapons rapidly and accurately, and to present appropriately filtered pictures of the air and weapons situation to Air Force personnel who conduct the air battle.

Several similar control systems such as one for processing intelligence information and one for weather information are under development.

SAGE—A DESCRIPTION OF ITS FUNCTION[2]

From the preceding discussion it is evident that real-time control systems differ significantly from current business and logistic management control systems. To better illustrate the nature and scope of such real-time activity, a brief description of the SAGE system may prove useful.

The semi-Automatic Ground Environment (SAGE) system is a vast interconnected network of air defense direction centers which receive information from many sources, process the information rapidly on AN/FSQ-7 Military Computers, display pertinent information to human decision makers and generate battle orders to jet interceptors and other weapons in the air defense system. SAGE centralizes the air defense system for the handling of information and direction of weapons.

The air defense system requires monitoring of all aircraft flights in the United States and around its perimeter to determine whether the aircraft are friendly or hostile. Since there are close to 50,000 scheduled flights in the United States every day (and many more that are not scheduled), it is necessary that SAGE operate on the "exception principle." The approach is to keep track of flights until they can be identified by several means, then reject further consideration.

AIR DEFENSE REQUIREMENTS

What are the management-like system requirements for integrated control of weapons defending a country from airborne attack? The various weapons and input sources involved are operated by the three military services; they are developed and improved by many different companies. As a result, control information requirements are diverse and non-standardized. The general requirements for an air defense control system may be stated approximately as follows:

1. Provide positive recognition of an air attack.
2. Provide up-to-the-minute status of defense capability.
3. Be capable of issuing immediate defense instructions.
4. Be operable immediately upon installation, at high efficiency.
5. Operate on a continuous basis with high reliability.
6. Be adaptable to a growing air defense capability.

A brief discussion of each of these points will bring out some of the problems faced by the system designers and implementers.

Provide Positive Recognition of an Air Attack

In order to recognize an air attack and its changing character during a battle, the following system capabilities are required:

1. *Surveillance* of the airspace in which air flights of hostile intent may occur. Detection of all aircraft movement.
2. *Monitoring* of all flights which enter, or could enter the air space. This means most of the flights in the country.
3. *Identification* of all flights monitored by matching and correlating with flight plans or other identifying information. When necessary, initiate direct means of identification by Air Force aircraft.
4. *Communicate* and *coordinate* information on a country-wide basis, with emphasis on adjoining areas and the next higher headquarters. This description of the air situation is necessary to determine whether an attack is present or imminent.

Provide Up-to-the-Minute Status of Defense Capability

To perform this function, the system must:

1. Keep all echelons informed as to the status of all the various weapons available.
2. Provide all echelons information on the immediate situation, both as to individual weapons and to the air and battle situation. This information must be suitably filtered, summarized and communicated for higher echelons.
3. Provide display and/or built-in decision-making means to permit rapid and accurate evaluation of alternatives in allocation, assignment and commitment of weapons.

Issue Immediate and Appropriate Defense Instructions

In order to provide immediate response and to effect control, the system must:

1. Disseminate decisions and orders without delay to those who will take the necessary action.
2. Direct, using rapid communication media, the various weapons to specific targets and control each to the degree required by the weapon design.
3. Display the defense-in-action on suitable consoles for management decision making.
4. Coordinate among all operating personnel, the various echelons, the military services and civilian agencies involved.
5. Human factors must be taken into account in the entire operation.

Be Operable, as a Man-Machine System, at High Efficiency, Immediately

The system must function effectively the first time an attack occurs and under conditions of high turnover of diversely skilled personnel. A means for the following must be provided:

1. Continual training of personnel in individual and team skills.

[2] Acknowledgment is made to R. C. Hopkins for his assistance in preparation of this material. A more detailed discussion of many points contained herein is found in (1).

2. Operate the system with simulated inputs to obtain experience in operation during an attack. A high degree of realism is necessary to properly exercise the system and bring it to a high level of preparedness.

Be Operable with High Reliability on a Continuous Basis

To operate continuously, a high order of reliability and maintainability is required. This involves a set of duplicate computers as well as duplicates of other equipment and alternate communication lines. This factor accounts for a large portion of the expense of the system.

Be Adaptable to Growing Air Defense Weapons Capability

In order for the system to grow and adapt to ever changing weapons technology, the system must have the following attributes:

1. The computer program must be modified to integrate new weapons that are continually being added to the defense. This necessitates the use of a general purpose, internally programmed, large storage capacity computer.
2. Changes in existing weapons, their control apparatus, etc. must be handled without undue delay and rearrangement of the whole system.
3. As a corollary to this, new characterization of attack configurations must be able to be added to the system.

THE SAGE SYSTEM

How were the complex and diverse requirements for an integrated air defense control system met? As one might expect from his experience in the automation of a portion of a business enterprise, the techniques and procedures in use which were developed over a long period of experience were not scrapped, but rather consideration of their automation was used as a starting point in the design of the new system. In all, development of the system involved the cooperation of thousands of individuals and the combined efforts of a large number of scientific, business and military organizations.

In order to meet the requirements listed, provision had to be made for the automation or semi-automation of the following:

1. Collection of information and data and elimination of noise therefrom.
2. Sorting, correlating and further processing of the information.
3. Generation of displays to permit human monitoring, decision making and intervention.
4. Displays must include a presentation of the air situation and be kept current.
5. Means for identifying individual aircraft in the air situation.
6. Filtered and summarized displays to permit high echelons to make general decisions about the situation.
7. Transmission of information and data to all points where it is needed.
8. Means for deciding about the use of weapons and for directing them against the attack.
9. Means for computing control information and transmitting it to the various weapons.
10. Means for system training.

FIG. 1. Map Showing Air Defense Sectors.

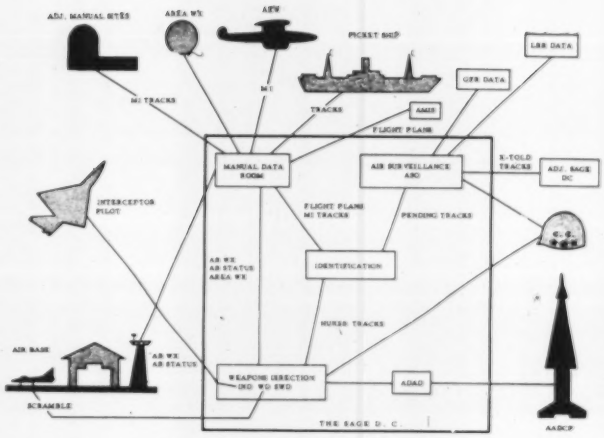

FIG. 2. SAGE Operations Inputs.

These many functions point up the size of the task and the need for a uniform description of the system design. SAGE was therefore designed as a network of interconnected direction centers as shown in Figure 1. Here are shown 26 SAGE Sectors organized into 7 SAGE Divisions. There is a direction center in each sector which receives information and data from many sources in its area—from radars about present positions of aircraft, from air traffic control centers about flight plans, from weapons bases about weapons status, etc. The direction center's data and information sources are shown in Figure 2. At each division level there is a combat center which has essentially the same functions and equipment as the direction center.

At each direction center, the man-machine operation is conducted in four principal places. These are, the Manual Data Input Room where information arriving by telephone or teletype is entered into the computer, an Air Surveillance Section where the machine make-up of the air situation is monitored and assisted, an Identification Section where the aircraft "tracks" shown in the air situation are identified by matching them with known flight plans and other known or requested information,

and a Weapons Direction Section where the individual interceptions of hostile aircraft are directed and monitored. In all, over 100 display consoles and some 65 military and civilian contractor personnel work in a SAGE Direction Center.

The network of long range and gap-filling radars which formed the basis of our air defense system before and during the development of SAGE are now connected to their direction center by means of automated digital data links. Similar links connect adjacent direction centers for the "cross-telling" of pertinent radar and other data. Real-time data on present aircraft positions are also relayed from "manual" direction centers (areas where SAGE is not operational) and from extensions to the radar net on ships and aircraft which range outward from our perimeter by telephone and teletype. This information is inserted into the computer by card punch entry equipment in the manual data room. Other information, entered in a like manner, are civil and military flight plans, weather information and weapons status, although some of the latter is by automatic data link direct to the computer input system, as is the radar and cross-tell data. Extensive voice communications are also available.

The direction center transmits output data by an automatic digital data link directly from the computer output system to certain weapons, to adjacent direction centers, to combat centers (higher headquarters), and to radar sites for requesting height information. Information is also fed automatically from the computer to teletype circuits to certain weapons systems, to adjacent manual direction centers, to higher headquarters, etc. Associated with one of the direction centers in each SAGE Division is a Combat Center where the next higher echelon or organization operates with filtered and summarized data from the direction centers under its command.

A REVIEW OF SAGE DESIGN FEATURES

The Direction Center is the smallest self-sufficient component in the SAGE system. The Direction Center is a man-machine data processing and on-line control complex, at the heart of which is a pair of large, high-speed, general purpose digital computers generally referred to as the Q-7 Military Computer. Associated with the computers are the necessary input and output systems and other auxiliary equipment. Two computers are "duplex" to provide the necessary reliability and maintainability. If one computer should fail the second can take over immediately. The magnitude of the SAGE task may be best realized perhaps by the fact that the operating computer program, which has to be designed to include every function of air defense in which the computer is involved, consists of approximately 100,000 individual instructions and that these programs, together with programs involved in system training and in the production of the programs themselves, involve on the order of a half-million instructions.

In Figure 3 the system design of SAGE is depicted in block form. Here the manner in which the human and automated decision-making activities are made, the closed loop feedback of control and monitoring information, and the central role of the computer are illustrated. Features of the SAGE system design include:

On-Line Control Features

1. Automated and semi-automated real-time assemblage of information from many sources.
2. High-speed communication of assembled information to the computer through input systems that provide for some monitoring and noise elimination, for sorting, temporary storage, and buffering between real-time and computer processing cycles.
3. Use of the above-mentioned automatic transmittal features for communication with many and various types of agencies and equipments including weapons systems, individual weapons, other computers, higher headquarters, height finders (requests for inputs), etc.

Decision-Making Features

1. Use of an on-line, man-computer, sample-data system for control purposes.
2. Use of an extensive, multi-informational, dynamic display system to permit human monitoring, intervention and decision making.
3. Use of on-line, low-level decision making by the computer.
4. Automatic display in real-time of decision alternatives by the computer.
5. Man assistance of and intervention in machine information processing by real-time monitoring.

Display Features

1. Use of approximately 4000 data selection buttons, 130 action buttons, and 64 light guns for direct communication between the operators and the computer.

Provision for Simulation

1. Built-in simulation and recording equipment and programming for system training.

Error Correction Features

1. Use of duplicate equipments and self-diagnostic and self-error-detecting maintenance procedures to achieve very high reliability in operation.

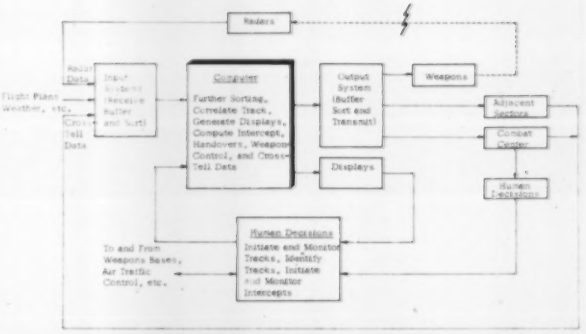
Radars
Weapons
Adjacent Centers
Combat Center
Displays
Human Functions
Flight Plans, Weather, etc.
Further Sorting, Correlate Track, Generate Displays, Compute Intercept, Handovers, Weapon Control, and Cross-Tell Data
Human Decisions
Initiate and Monitor Tracks, Identify Tracks, Initiate and Monitor Intercepts
To and From Weapons Bases, Air Traffic Control, etc.

FIG. 3. Conceptual System Design of SAGE.

Data Processing Features

1. Use of a general purpose information processing and computing device with large and readily available information storage capacity and with very high speed computing capability.
2. Automatic real-time transmittal of control and other operational information in digital form through a versatile output system that sorts information according to destination and acts as a buffer between computing cycles and transmitting equipment.
3. Use of a large integrated computer program of some 100,000 instructions which includes and ties together 100 subprograms and handles thousands of types and varieties of information, controls the sequence of operations of all subsystems, performs all information handling and computing tasks, and assists in evaluation of alternatives and in decision making.

A comparison of the SAGE computer itself with some of the modern scientific commercially available computers may be of interest. The SAGE computer was designed in the period 1951 to 1954. Since the computer is produced by the International Business Machines Company who, together with Massachusetts Institute of Technology's Lincoln Laboratory, also created the design, it is most appropriate to make a few simple comparisons with the latest of IBM's computers. Table 1 compares the SAGE computer (two of which are in each direction center) with the IBM 704, 709, 7090, and the Q-7A employed in the combat center.

APPLICATION OF SAGE EXPERIENCE TO THE DESIGN OF MANAGEMENT CONTROL SYSTEMS

The SAGE experiences can be appraised from several standpoints. The hardware, the air defense characteristics, and the computer programming, are a few. The purpose here is to explore the experience from the point of view of the manager who must initiate effective programs, provide sufficient resources and develop a proper organization for the system. The following may offer guidance to managers who desire to develop a real-time management control system.

SYSTEMS ANALYSIS APPROACH

In reviewing the development of SAGE one is impressed, first, with the fact that several years were taken in its design. Further, as has been pointed out, in designing a system of this magnitude the primary focus was on determining precise system requirements. Thus, in many respects SAGE has evolved from answering the question, "What must we have in the way of a system?" to asking "What can we do to improve or automate existing practices?". As we look over the current process of creating new management control systems in either the military or in industry, it becomes obvious that the latter approach is often the easiest to justify and has therefore been the traditional route.

The design process stemming from asking the former question, which in essence becomes "What is the best system?", is often called the systems analysis or systems engineering approach to the problem. Thus, one principle in creating a new system involves a careful look at the requirements of the system via the systems engineering approach. A list of steps involved in this approach follows:

Establish criteria for management information needs

1. Determine current information, decision, display, and report practices, using a graphical flow form.

TABLE 1

Comparison of Computer Characteristics

Characteristics	AN/FSQ-7 (SAGE Computer)	IBM 704	IBM 709	IBM 7090	AN/FSQ-7A (Improved SAGE)
Word Length (Bits)	32	36	36	36	48
Min. Computation Cycle (μ secs.)	12	24	24	4.8	2.5
Max. Random Access Storage Capacity (Bits)	2,228,224	1,179,648	1,179,648	1,179,648	3,932,160
Random Access Storage Time (μ secs.)	6	12	12	2.4	<2.5
Max. Drum Storage Capacity (Bits)	4,765,592	294,912	294,912	None	13,369,344
Total Maximum Internal Storage (Bits)	6,993,816	1,474,560	1,474,560	1,179,648	17,301,504
Max. Number of Tape Units	6	10	48	64	16
Card Readers or Entry Punches	4	1	3	8 Each	1
Output Printers	1	1	3	8	1
Live Input-Output Features	Yes	Not Included in Design			Yes
Tubes (Approx.)	58,000	5,000	10,000	(Transistorized)	(Transistorized)

Make preliminary system design

1. Develop a preliminary statement of system requirements, i.e. specify reporting frequencies, types and routing of reports, type of equipments, displays, etc.
2. Determine what to automate or computer program and what to leave as currently performed.

Evaluate preliminary design

1. Determine hardware cost, training implications.
2. Assess the nature of the improvement to be gained.

Develop a revised model of the proposed system

1. Test the design using the systems analysis approach.
2. Use of an approach involving simulation or gaming to obtain the participation of the ultimate users.

Develop system specifications

1. Install, de-bug, modify, extend the system.

SYSTEMS TRAINING APPROACH

In providing a major resynthesis such as the SAGE system, it has been found necessary to train people in the new methodology. Training in SAGE involves elaborate computer simulations of a predicted attack environment. This requirement represents a new concept to the management world. Basically, the justification for elaborate training stems from the fact that there is no other way to adequately prepare people for the acts that they would have to perform under a real attack situation.

An important additional value in this approach is the proficiency obtained by operating the system as a whole, involving the communications and interrelations of many people and machines. The proficiency of individuals, then, is properly judged by measures in the total system context. One would not want to, for example, emphasize performance at one part in the system that would act to the detriment of the total system. To adequately demonstate proper performance in such a broad system, a comprehensive means of training using simulated exercises has been provided. In short, one wants to train each person to act in an optimal way from the total system point of view. Thus whether the environment is real or hypothetical (as in SAGE) is not the only factor in determining the need for simulation in training.

Thus, if a drastically new concept of management control is to be developed, it appears quite likely that the installation time, the acceptance, and therefore even the ultimate efficiency attainable by the system, will be considerably enhanced by appropriately designed simulation exercises along with proper criteria for measuring individual performance in relation to total system performance.

ORGANIZATIONAL DYNAMICS

In the design and implementation of SAGE, the ability to centralize many activities has been made possible. As the Air Force perceived the comprehensive changes in the Air Defense Command structure required to support these concepts, it organized the air defense function more centrally, using the control system as the guiding structure. Further, in developing the over-all SAGE system itself, it was found necessary to create a proper management organization to guide the process of design and implementation. The concept of a system manager, or ESSPO (Electronic Support Systems Project Office), has come into being with the mission to properly manage the joint efforts of system analysis, system design, computer manufacturer, computer programming, and system training activities.

While the following is a very broad generalization, it would appear the quickest route to effective development of a truly integrated management control system involves proper points-of-view on the part of management in regard to the possible effects on organization; that is, the possibility of recentralization and elimination of certain functions must be within the system designer's scope. In addition, it appears necessary that the organization to perform the system analysis must have proper organizational status itself and that top management plan for the necessary lead time for this activity. While quite evident, the thought should be emphasized that top management support and participation is vital in order to obtain results.

ADVANCES IN MANAGEMENT TECHNIQUES

On-Line Control—A Technical Achievement

The SAGE system has proven that an on-line, direct read-in read-out, integrated computer operation is possible. This is an important technical achievement that can have significant implications in the management controls area. The feasibility of utilizing this feature can best be determined by a systems analysis bringing out the cost and effectiveness of the application.

Management-By-Exception[3]

The large data processing capacity available in SAGE made possible a centralized operation with large masses of data carefully sorted by built-in criteria. The outputs presented to the decision maker are only the exceptions requiring attention. This feature could be extended in current management control systems on a centralized basis.

Interrogation, or Fast-Simulation Possibilities

The ability for the human monitor to ask the computer certain questions like "what would happen if I issued this order?" has been also demonstrated on SAGE. This interrogation feature, utilizing "fast-simulation,"

[3] Examples of this feature are found in certain military management controls. For example, the PERT system in the Navy Polaris program permits all of the planned activities in that program to be monitored centrally by the exception principle (3).

requires the building of analytic models for desired predictive purposes. Using appropriate models, this capability can be applied in an on-line basis in management control systems.

PRECISE FORMULATION OF OBJECTIVES FOR COMPUTER PROGRAMMING

In utilizing computer-based systems it has become quite evident that there is need for precise formulation of what's to be done by the computer program and precise, as well as concise, computer programming languages. In this regard considerable activity is required; first, to develop precise statements of objectives, translate them into appropriate analytic models of the problem and thence into operational instructions, for the computer programming task; secondly, to recognize and participate in the development of appropriate computer languages to facilitate the large labor involved in computer programming and; thirdly, to develop and test adequate decision-making criteria required in the formulation of those functions to be automated. This field of computer programming development requires considerable augmenting in building total system management controls.

To perform the computer programming task—perhaps the most complex, difficult and time consuming task, has been the increasing refinement and coverage expected of SAGE as new weapons are added. The computer program must be comprehensive enough to handle a wide variety of possible situations and must include precise rules (or formulae) for handling these situations. Specifying these rules—making certain they are the right ones, are efficient, etc.,—is a task referred to as formulation. Once the situation to be controlled is recognized and the rules are determined, the task of designing the program can be done.

The point of these remarks is to stress the need for continued research in the area of computer programming techniques in view of the fact that it is a very rapidly changing technology. It appears likely that any approach to systems design will involve a team of many skills, including engineers, mathematicians, psychologists, statisticians, computer specialists, management and system specialists.

BUSINESS MANAGEMENT CONTROL SYSTEMS RESEARCH

The remarks of Leavitt and Whisler in their provocative article, "Management in the 1980's," are appropriate at this point (2). Perhaps the way of Management Control Evolution may be epitomized by their observation concerning the growing "information technology":

> . . . the upshot of Taylorism (Scientific Management, Industrial Engineering Approaches) seems to have been the separating of the hourly worker from the rest of the organization, and the acceptance by both management and the worker of the idea that the worker need not plan and create. Whether it is psychologically or socially justifiable or not, his creativity and ingenuity are left largely to be acted out off the job in his home or his community. One reason, then, that we can expect top acceptance of information technology (automatic decision making in effect) is its implicit promise to allow the top to control the middle just as Taylorism allowed the middle to control the bottom.

It has not been the purpose of this discussion to assert positively that the approach in military real-time control systems, which has been quite effective in the military application, is either necessary or practical cost-wise in the management control domain. While the concept appears quite promising, these are questions that can only be resolved by further study. The possibility of developing a comprehensive, integrated, total company on-line controlling concept is worth serious study. If the lead time can be reduced in arriving at the desiderata of truly designed information-communication systems, a significant contribution to the management field would be made.

To explore the nature of the research, a project in Business Management Control Systems Research has been established. This research project is aimed at developing a generalized computer model of a business, one which will permit experimentation with certain policies, procedures and organization (5). Hopefully, this research will lead to some answers to questions concerning cost and effectiveness of various management control system approaches. The results may some day permit us to truly design management control systems that are more nearly optimum from all points of view.

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Industrial Engineering and Mathematics at the Department Head Level[1]

by **MELVIN R. WITMER**[2]

Industrial Engineering Division, Eastman Kodak Company

Van Ross is plant manager. His plant manufactures casings. Smith is department head. His department packages casings. Van Ross is talking to Smith on the telephone.

Van Ross—Smith, I have your labor analysis sheets for March.

Smith—Um.

Van Ross—What goes with your direct packaging labor? You're 10% over standards this past month!

Smith—Overtime. We had some bad days and had to work a couple of Saturdays.

Van Ross—What about maintenance? It's up another notch again.

Smith—More downtime. You know we can't afford to let our packaging machines sit idle. The investment is too great. We had to get another mechanic.

Van Ross—This looks like your month, Smith. You scored 100%. You're up in your inspection costs too. Did you get another inspector?

Smith—Had to. Those tighter specifications you sent down are giving us more rejected work than we figured on.

Van Ross—Look, Smith, this spiral has got to stop. Our costs are going up each month.

Smith—Um.

Van Ross—Let's keep them in line. Looks bad at the home office when our costs are continually over last month's figures.

Smith—Um.

The case of "Van Ross and Smith versus Spiralling Costs" is common. For some years now, adequate methods have existed for controlling direct labor costs—at least Van Ross knows that Smith is "10% over" in direct costs. But Van Ross does not know where Smith stands on maintenance or inspection costs. All that Van Ross knows is that indirect costs in these two areas are going up.

Smith's problem is aggravated by the fact that his indirect costs are becoming a bigger and bigger part of total product cost. Smith, and many of Smith's counterparts all across industry, need better methods for controlling indirect costs. This section proposes a method for establishing maintenance labor and inspection labor standards.

THE MAINTENANCE PROBLEM

Smith may have been wrong in one thing he told his boss. Smith's comment, ". . . we can't afford to let our packaging machines sit idle . . .", may have been in error.

When a group of mechanics service a battery of automatic machines which have random breakdowns, there are generally two extremes in cost. One extreme is to have too much downtime as a result of not having enough mechanics. (This is what Smith wanted to avoid at all costs.) The other extreme is to have too many mechanics. The costs of these extremes are shown in Figure 1.

Cost of mechanics is proportional to the number of mechanics in the group. Downtime costs decrease as mechanics are added to the group. The more mechanics, the less the machines have to wait for service. Adding these two costs gives the total cost curve. The minimum point indicates the optimum balance between excessive downtime costs and excessive maintenance costs.

Smith's department may have been operating at the minimum point. But chances are, it was not.

Let us take a look at Smith's problem and find the answer he should have given Van Ross on maintenance.

Smith's packaging department packages about 7 thousand casings in a four week period. To do this, Smith has 20 automatic machines. One operator runs two machines. Machines have breakdowns at random intervals and re-

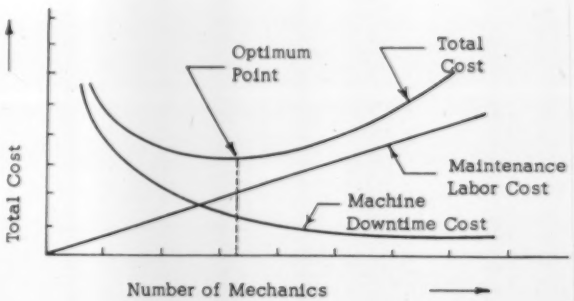

FIG. 1. Effect of Mechanics on Cost.

[1] Based upon a presentation to the Rochester Chapter, American Institute of Industrial Engineers, February 1, 1959.

[2] The writer expresses his appreciation to Edward J. Carstens, Gordon L. Fiske, Elmer W. Same, Jr., and Daniel E. Suter for their kind assistance in the work reported and in the preparation of this article.

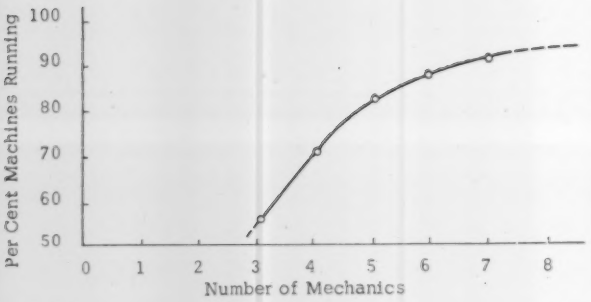

FIG. 2. Results for 20 Machines: Average Machine Run Time versus Number of Maintenance Mechanics.

quire the service of a mechanic. When mechanics are not needed on the machines, they are non-productive—there is no fill-in work. Smith had 6 mechanics, and last month added a seventh to further minimize the time his machines were down waiting for a mechanic. Did Smith make the right decision?

Before this question can be answered, we need answers to the following questions:

1. What are the total costs using 7 mechanics?
2. What would the costs be if Smith had 8 mechanics? 6 mechanics? 5? 4? 3? 2?

What are total costs now? Analysis of historical data shows that the present variable unit cost, with 20 machines and 7 mechanics is $.4/1000 units.

What would the total costs be if Smith had 8 mechanics, etc.? The answer to this question involves the use of "waiting line" equations or simulation to estimate the amount of run time which could be expected if there were more or less than 7 mechanics.

Developing the answer mathematically or by simulation is generally more practical and faster than making actual changes in the labor force and later observing historical data.

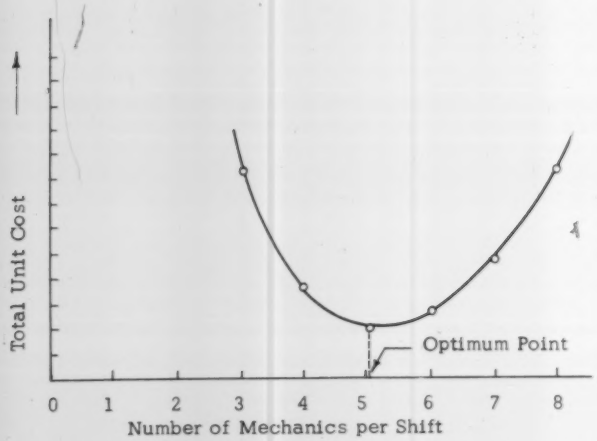

FIG. 3. Variable Cost for 20 Machines: Cost versus Mechanics for a 4 Week Requirement of 7,000 casings.

The results from the use of the waiting line equations show that for each different assignment of mechanics to machines, a value of average run time can be predicted. These results are shown in Figure 2.

As one would expect, average run time increases with an increase in the number of mechanics in the group.

Graphing the results of cost calculations for various numbers of mechanics shows the relationship between cost and mechanics, Figure 3.

Now, Smith's decision to add another mechanic can be evaluated. Minimum total cost occurs with 5 mechanics servicing 20 machines. Smith's drive to "keep the machines running" caused him to overlook the cost of idle maintenance labor. Balancing both the cost of machine idle time and the cost of mechanic idle time will help Smith reduce maintenance costs.

Results such as those in Figure 3 indicate the direction

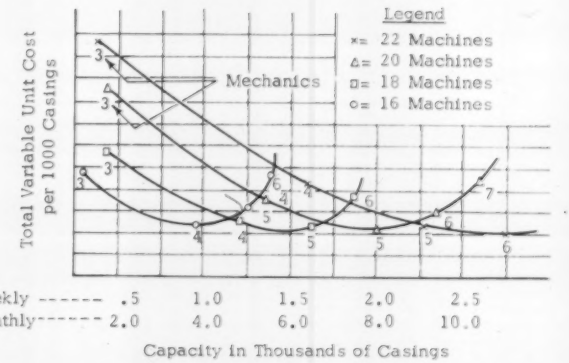

FIG. 4. The Maintenance Model: Total Cost versus Capacity.

for Smith to be headed. But, let's be practical. Smith's schedule is not constant. What about the months when the schedule calls for 5 thousand casings or 8 thousand casings instead of the average of 7 thousand?

For periods of low schedules, Smith's recourse in the past has been to cut back the number of machines operating. But what happens to the maintenance crew if only 16 or 18 machines are scheduled?

In the same manner that unit costs were determined for combinations of 20 machines and 3 through 8 mechanics, they can be determined for groups of 16, 18 and even 22 machines. For each assumed situation, the average run time is determined from waiting line equations, unit costs determined, and capacity calculated. The results are shown in Figure 4.

Smith now has a useful tool. It can be used in day to day scheduling, in establishing maintenance labor standards, and in making decisions on new equipment.

Scheduling—Given a month's or week's schedule, Smith can plan to use the combination of machines, operators, and mechanics which will yield minimum cost.

Maintenance Labor Standard—For a week's schedule of 2 thousand casings, Smith can expect to use 600 total

	Previous Quality Limit 3% Defective	New Quality Limit 2% Defective
Labor Required per year	25,000 hours	47,900 hours
Labor Cost per year	$100,000	$192,000

FIG. 5. Comparison of Inspection Systems.

maintenance hours. (5 men × 8 hours/shift × 3 shifts/day × 5 days/week = 600 hours.) To this standard, he can compare the actual hours incurred.

Deciding on additional equipment—Smith has a convenient means for making a decision on purchasing additional machines. The cost of expanding capacity by purchasing additional machines can be compared to the cost of expanding capacity by adding more mechanics.

CONCLUSION

Day by day and week to week decisions on the number of machines and operators to schedule and the amount of maintenance to provide are all based on minimum cost criteria. *This is using results of mathematical techniques at the department head level.*

THE INSPECTION PROBLEM

Smith was on the defensive on inspection costs. Last month Van Ross sent down tighter quality specifications. Smith thought he could live with them and did not plan for any additional labor.

Things are not working out that way. Smith is having more rejected work than he planned, has boosted his inspection labor, and is now being nailed from "the top" for letting his costs get out of hand.

Smith's answer to this problem should have started last month—when the new specifications came through. At that time, Smith should have prepared a quantitative answer as to what the new specifications would mean in terms of labor. He would have been able to predict the recent upswing in labor requirements, and could have met any objections with cold, hard facts—such as those in Figure 5.

With the facts, Smith can show Van Ross how much the tighter specifications will cost. But this is not enough. What Smith should do is show Van Ross *how much* actual improvement in quality will result. Let's help Smith prepare an answer for Van Ross on this one.

Smith's packaging machines have averaged 1.3% defective over a long period of time. From week to week it may range from ½% defective to 5% defective. In the past, specifications on casings called for an outgoing quality limit of 3% defective. To meet this requirement, Smith was using a well-planned continuous sampling plan. There were four inspectors each shift.

Now the quality limit on outgoing lots of casings is 2% defective. Smith had new acceptance points developed for the continuous sampling plan so that the outgoing quality limit would be 2% defective. Smith was shown an operating characteristic (O.C.) curve for his new plan. (Things seem to be in order.) But at this point, Smith's information stopped. Labor requirements were not predicted from the O.C. curve nor was an estimate made of the actual improvement in quality. Figure 6 shows the information Smith should have received.

With facts like these, Smith could have presented Van Ross with an analysis of what the cost increase and improvement in quality would have been for tighter specifications. If Van Ross still wanted to tighten specifications after seeing all the facts, he would have done so knowing that next month Smith's inspection labor would be increased.

WHAT ABOUT AN INSPECTION LABOR STANDARD?

The preceding analysis is fine for evaluating the effect of changing specifications. But what is Smith to do on a day to day or week to week basis?

In Smith's department inspection labor depends on the amount of production and the amount of rejected work which has to be sorted. The overall percentage of production which has to be inspected varies. Some weeks are good, some are bad.

The tool that Smith needs is one which will allow him to set an inspection labor standard. Actual performance could then be compared to the standard.

In Smith's weekly quality reports he receives an estimate of average incoming percent defective and a report on total production. Using these two facts from his weekly reports, Smith can use the chart in Figure 7 to find the "standard" inspection hours for the past week. He can compare actual performance to this standard.

In addition to enabling Smith to arrive at an inspec-

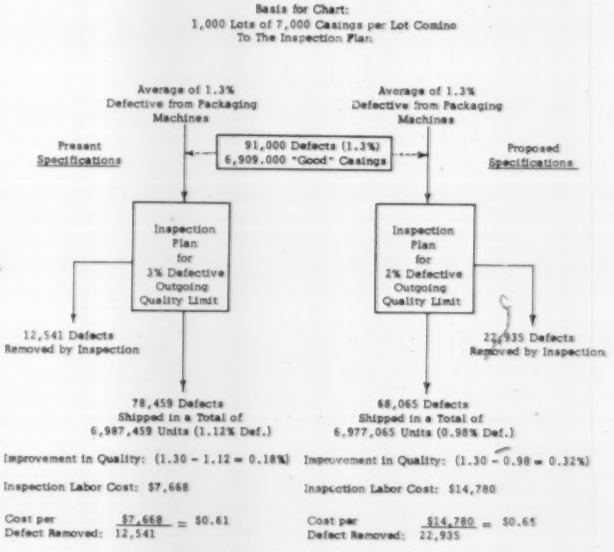
Basis for Chart:
1,000 Lots of 7,000 Casings per Lot Coming To The Inspection Plan
Average of 1.3% Defective from Packaging Machines
Average of 1.3% Defective from Packaging Machines
Present Specifications
91,000 Defects (1.3%)
6,909,000 "Good" Casings
Proposed Specifications
Inspection Plan for 3% Defective Outgoing Quality Limit
Inspection Plan for 2% Defective Outgoing Quality Limit
12,541 Defects Removed by Inspection
22,935 Defects Removed by Inspection
78,459 Defects Shipped in a Total of 6,987,459 Units (1.12% Def.)
68,065 Defects Shipped in a Total of 6,977,065 Units (0.98% Def.)
Improvement in Quality: (1.30 - 1.12 = 0.18%)
Improvement in Quality: (1.30 - 0.98 = 0.32%)
Inspection Labor Cost: $7,668
Inspection Labor Cost: $14,780
Cost per Defect Removed: $7,668 / 12,541 = $0.61
Cost per Defect Removed: $14,780 / 22,935 = $0.65

FIG. 6. Comparison of Present and Proposed Inspection Systems.

tion standard, the chart shows dramatically the advantages of keeping the incoming percent defective low.

From this chart, Smith can estimate how much engineering time can be spent on further improving the machines to improve quality. Smith is close to the machines. He can take the initiative in planning quality improvements. He knows how much he can afford to spend on changes which will decrease the percent defective a significant amount. He may be able to shift the emphasis from spending money to sort out defects to spending effort to prevent them from being produced in the first place.

This is Industrial Engineering and mathematics at the department head level.

Van Ross has Smith on the telephone.

Van Ross—Smith, I have your labor analysis sheets for June.

Smith—Yes?

Van Ross—What's this "maintenance-standard-hours" figure? I didn't know you had one.

Smith—Our engineers have helped us set up a method of balancing downtime costs with maintenance costs. That standard is the amount of maintenance we should have used for our month's production. We were over this month, but we know what happened, and by next month we should hit our standard.

Van Ross—Balancing costs, eh? How did you do that?

Smith—Well, you see, when you've got a situation like ours, you need to look at . . . and that's about it, the systems are in and working.

Van Ross—Say, Smith, bring those maintenance and inspection charts along over to the office with you. I'd like to talk to you more about this. I think you have something the home office would want to know about.

CONCLUSIONS

With more refined techniques available for solving problems, there may be a tendency for Industrial Engineers to become technique-oriented. But techniques to the department head are not important. The value of Industrial Engineers in the future, as it has in the past, depends on results, not techniques.

Effort must be applied to insure that:

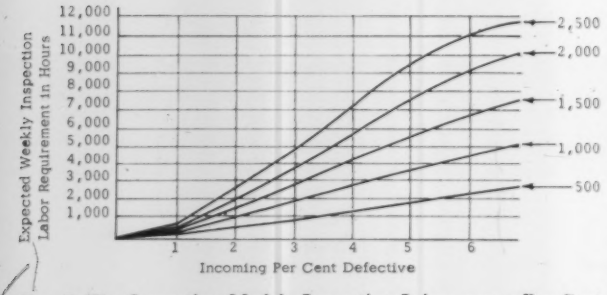

FIG. 7. The Inspection Model: Inspection Labor versus Per Cent Defective at Different Weekly Production Levels.

Results of mathematical or simulation solutions to industrial problems are practical.

Results are in a form easy to use by production personnel.

Results are permanent. Here are the results for today. Will they be useful tomorrow when our production rate goes up? When the new machines arrive? When the labor force gets a general rate increase? When quality specifications are changed?

This is one of the challenges to the Industrial Engineer who applies mathematical solutions to industrial problems.

SECTION II

This section presents two important points—one is the theory behind the models presented in the preceding section, the other is the problem of keeping these models up to date in the face of changing conditions.

This latter point is real. Today, much of the effort of Industrial Engineers is spent on the maintenance of existing standards. Changing conditions are just as much a threat to inventory models, maintenance models, inspection models, and scheduling models. Changes should be expected and planned for in the model.

THE INSPECTION PROBLEM

Theoretical Considerations—The inspection model is an extension of sampling plan calculations. From the operating characteristic curve for each sampling plan, it is possible to predict the amount of work which will be accepted, retested and rejected.

Figure 8 shows the incoming lots which Smith can expect to accept, retest, and reject at certain defect levels. "Units inspected" is then translated into labor requirements. This final step of including labor analyses based on statistical sampling plans is an important step to the department head using the plan.

Keeping the Model Up to Date—Changes in defect levels of many operations occur frequently, particularly on a short term basis. It is often these occurrences of short term variations which cause a department head to question the adequacy of the statistical sampling plan.

Relating labor requirements to changing defect levels and changing production levels gives the production department head an understanding of causes behind fluctuating labor loads.

The inspection model presented in the preceding section of this article can adapt to changes in production and defect levels. A change in quality *specifications* or a change in inspection *methods* would necessitate basic changes in the model.

THE MAINTENANCE PROBLEM

Theoretical Considerations—The maintenance model in the first section was developed from results of waiting line calculations made for different combinations of machines and mechanics. Waiting line calculations were used to predict average run time for machines serviced by mechanics.

Basis for Chart: 1000 lots, 7000 Casings per Lot
Sample 125/lot —Accept lot on 4 or less defects
—Retest lot on 5, 6, or 7 defects
—Reject lot on 8 or more defects
Retest 300/lot —Accept on 7 or less defects
—Reject on 8 or more defects
Assumed incoming quality = 1.3% defective

% Defective Incoming Quality	No. of Lots	SAMPLE			RETEST		TOTAL	
		Accepted	Retest	Reject	Accept Retest	Reject Retest	Acc.	Rej.
0	300	300	0	0	0	0	300	0
1	340	337	3	0	3	0	340	0
2	210	187	23	0	17	6	204	6
3	90	62	24	4	8	16	70	20
4	30	13	13	4	1	12	14	16
5	10	3	4	3	0	4	3	7
6	10	1	4	5	0	4	1	9
7	5	0	1	4	0	1	0	5
8	3	0	1	2	0	1	0	3
9	2	0	0	2	0	0	0	2
Totals	1000	903	73	24	29	44	932	68

Total Inspected:

Sample	1000 lots	× 125	= 125,000
Retest	73	× 300	= 21,900
Sort	24	× 7000	= 168,000
Sort	44	× 6700	= 294,800
Total			609,700

$$\% \text{ Inspection} = \frac{609,700}{7,000,000} = 8.7\%$$

Total Defects Present = 1.3% × 7,000,000 = 91,000

Defects Removed:

Initial Sample	= 1.3% × 125,000 =	1,625
Retest	= 3.2% × 21,900 =	700
Sort	= 5.6% × 168,000 =	9,408
Sort-Retested lots	= 3.8% × 294,000 =	11,202
Total		22,935

Defects Sent Out = 91,000 − 22,935 = 68,065

FIG. 8. Analysis of Inspection Plan.

Before analytical equations could be used to calculate run time, data had to be tested to determine if frequency distributions of *machine run time between service calls* and *mechanics' service time per call* followed the Poisson-type distribution. However, if the distributions were not of the Poisson type, a simulation technique could be used.[3]

Whether a mathematical or a simulation model is used, the objective is the same: to estimate machine effectiveness. From this estimate of effectiveness, unit costs and monthly or weekly capacities can be calculated.

Keeping the Model Up to Date—The maintenance model (Figure 4) that our department head, Smith, used, included one built-in "hedge"—a hedge against systematic changes in production.

Other changes which are likely to occur are:

1. Changes in machine production rates.
2. Changes in pay rates for operators and mechanics.

These would be planned changes. Another change which would have a creeping effect would be a change in service requirements of the machines. This could evolve in several ways: machines getting older could gradually cause more maintenance, or as mechanics improve service time may decrease.

PLANNING FOR THESE CHANGES

The minimum point on each curve of the maintenance model of Figure 4 represents the optimum balance between downtime costs and maintenance costs.

Maintenance cost is the labor cost of mechanics. But what are downtime costs? When machines are down, the operator and machine are both idle, unable to produce. Machine cost is fixed, unless as a result of an extreme amount of downtime more machines have to be purchased to build up capacity. In most cases, the *variable* downtime cost is the cost of having the operator idle. It is this operator cost which is the downtime cost in the

[3] Both waiting line theory and simulation are being used more and more by Industrial Engineers as an aid in quantifying problems in areas other than machine maintenance. Some inventory type problems, for example, can be quantified by waiting line models.

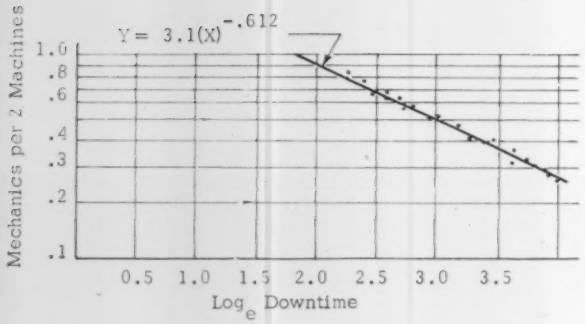

FIG. 9 Mechanics per 2 Machines versus Downtime per Machine.

maintenance model presented. Repeating, the minimum point on each curve represents the *optimum amount of downtime* for each machine or operator.

What effect does an increase in machine speed have on total costs? If the annual requirement does not change, an increase in machine speed would indicate that since the machine can turn out more production per unit run time, it can afford to be down more of the time. Hence, the optimum balance may shift in favor of fewer mechanics, allowing machines to wait longer for the services of a mechanic.

What effect does an increase in pay rate for operators have on total costs? An increase in operators' pay means that downtime costs *increase*. The optimum balance may indicate more mechanics should be used to further reduce time that machines have to wait for service.

These changes did arise in Smith's department. The question is, what model can be developed today that will be able to adapt to these changes? The following is the answer Smith received:

BACKGROUND

There are 20 machines in the department. Two machines are set up in one battery. One operator runs 2 machines.

When any one of the machines is running, the operator is paid $\$R$ per hour. When both machines are down, the operator is paid $\$D$ per hour. When both machines run at the same time, the production rate is P_2 units per hour. When only 1 machine runs, the production rate is P_1 units per hour. The mechanic is paid $\$M$ per hour.

It was found that the number of mechanics per two machines could be related to the amount of downtime per machine, Figure 9.

This relationship provided a means of stating the number of mechanics per 2 machines in terms of downtime.

$$\frac{\text{Mechanics}}{\text{2 machines}} = 3.1\ (\text{downtime})^{-.612}$$

Using the foregoing information an expression can be derived for total cost as a function of mechanics cost and downtime (operator labor) cost.

$$\text{Total Variable Labor Unit Cost Per 1000 Units} = \frac{(\text{Operation Cost}) + (\text{Maintenance Cost})}{\frac{1}{1000}(\text{Total Production})}$$

On the basis of 2 machines scheduled for 100 actual hours, the cost relationship is:

$$\text{Operation Cost} = \begin{bmatrix}\text{Operators' Rate for}\\ \text{"Machines Running"}\\ \text{Condition}\end{bmatrix} \times \begin{bmatrix}\text{Hours Out of 100 in}\\ \text{Which Either or}\\ \text{Both Machines Run}\end{bmatrix} + \begin{bmatrix}\text{Operators' Rate}\\ \text{When Neither of the}\\ \text{Machines Run}\end{bmatrix} \times \begin{bmatrix}\text{Hours Out of 100 in}\\ \text{Which Both Machines}\\ \text{are Down at Same time}\end{bmatrix}$$

$$\text{Maintenance Cost} = \begin{bmatrix}\text{Mechanic's}\\ \text{Rate}\end{bmatrix} \times \begin{bmatrix}\text{100 hours}\end{bmatrix} \times \begin{bmatrix}\text{Average No. of}\\ \text{Mechanics per}\\ \text{2 Machines}\end{bmatrix}$$

$$\text{Total Production} = \begin{bmatrix}\text{Avg. Prod. Rate/Hr.}\\ \text{When 2 Machines}\\ \text{Run}\end{bmatrix} \times \begin{bmatrix}\text{Hours Out of 100}\\ \text{That 2 Machines}\\ \text{Run}\end{bmatrix} + \begin{bmatrix}\text{Avg. Prod. Rate/Hour}\\ \text{When Only 1 Machine}\\ \text{Runs}\end{bmatrix} \times \begin{bmatrix}\text{Hours Out of 100}\\ \text{That Only 1 Machine}\\ \text{Runs}\end{bmatrix}$$

Let

Y = Total unit cost/1000 units

$\$R_{op}$ = Operator's rate when machines are running

$\$D_{op}$ = Operator's rate when machines are not running

$\$M$ = Mechanic's rate

P_1 = Average units produced per hour when only 1 machine runs

P_2 = Average units produced per hour when 2 machines are running

X = Hours of machine downtime out of 100 actual hours/machine

$100 - X$ = Amount of machine run time out of 100 actual hours

$\frac{X^2}{100}$ = Hours out of 100 that both machines will be down at the same time (approximation)

$\frac{(100-X)^2}{100}$ = Hours out of 100 that both machines will run at the same time.

$\frac{\text{Mechanics}}{\text{2 Machines}} = 3.1\ (\text{Downtime})^{-.612} = 3.1(X)^{-.612}$

Using the preceding symbols the cost relationship in terms of machine down time is:

$$\$Y = \frac{\left[\$R\left(100 - \frac{X^2}{100}\right) + \$D\frac{X^2}{100}\right] + \left[(\$M)(100)\left(\frac{3.1}{X^{.612}}\right)\right]}{\frac{P_2}{1000}\left[\frac{(100-X)^2}{100}\right] + \frac{P_1}{1000}\left[100 - \frac{(100-X)^2}{100} - \frac{X^2}{100}\right]}$$

When the actual values for $\$R$, $\$D$, $\$M$, P_1 and P_2 are put into the equations, total unit cost is related to downtime. Differentiation and solution of the equation will give the minimum cost and the optimum amount of downtime. This downtime can be translated into the optimum number of mechanics per 2 machines.

The ratio of mechanics per 2 machines is multiplied by the total pairs of machines to obtain the number of mechanics for all machines.

Limitations—The equation can be used for determining mechanic requirements:

1. As long as the total number of machines is between 10 and 22.
2. As long as there is no significant shift from present maintenance requirements.

Uses of the Equation—If conditions on which the original maintenance chart was based do not change, the chart can be used as a tool in scheduling. However, if pay rate changes occur, or if machine productivity changes, these changes should be made in the equation and a new optimum determined.

The change that is not covered in this equation is a shift in basic service requirements of the machines. The parameter used to describe service requirements is the ratio of *average service time per call* to *average machine run time between service calls*. This ratio is called the "service factor." As machines get older, or as mechanics improve, this ratio may shift. The question is: how much can it shift before the model should be up-dated?

A general answer is not adequate. The upper and lower limits have to be established for each problem. The way to arrive at an answer is to assume a 5% increase or decrease in this value and test the effect of this difference. Similar tests can be made for shifts of 10% or 15%. In this manner, the critical point can be established.

When the critical point is established a control chart technique (Figure 10) can be used to record weekly estimates of the service factor. In Smith's department data are tabulated in a manner such that this ratio is determined efficiently.

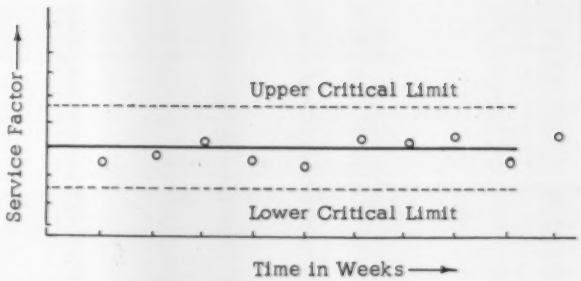

FIG. 10. Control Chart on Service Factor.

When the ratio has shifted beyond the critical point, the system should be re-evaluated in terms of the new service factor.

SUMMARY

Known changes can be incorporated in the proposed maintenance model so that "new" optimum operating crews can be calculated rapidly with little additional engineering effort.

Creeping changes can be followed by plotting pertinent information on a control chart. When the system is "out of control" the model should be updated to include these changes, or perhaps steps should be taken to reduce the service factor to its previous range.

CONCLUSION

The development of a good model, whether for maintenance, inspection, scheduling or inventory, costs quite a few engineering dollars.

Without thorough planning, the result is apt to be a static model in a dynamic situation. Benefits of this kind of model will obviously be short-lived.

Engineers who develop models must keep next year's changes in full view. Today's model must be dynamic and fit tomorrow's problems.

This is another one of the challenges to the Industrial Engineer applying mathematical techniques.

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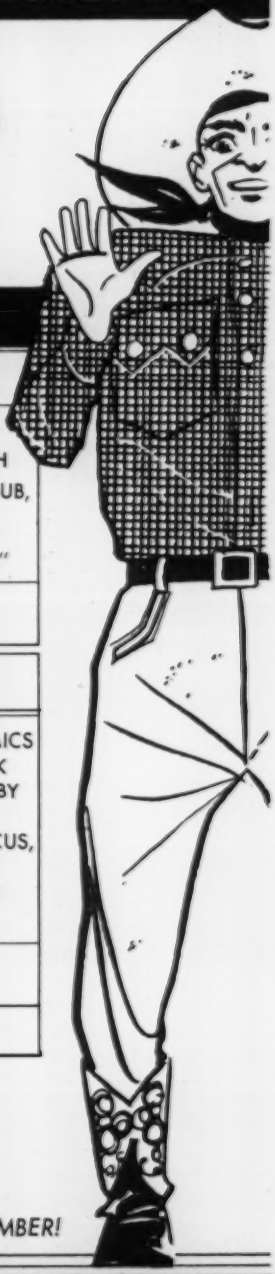

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The Management, Engineering, and Scientific Functions*

by HAROLD O. DAVIDSON

Vice President, Industrial Engineering, Operations Research Incorporated

IN SOMEWHAT less than two decades there has been phenomenal progress in the formulation and solution of mathematical problems that are analogical in useful ways to certain practical problems in the planning and direction of human enterprises. "Linear Programming" and "Queueing Theory," for example, are already familiar terms in the literature of Industrial Engineering. Familiarity with the techniques has also expanded as an increasing number of schools have brought them first into the graduate and then the undergraduate curricula, while older graduates have donned their skull caps again to keep sight of the expanding frontiers. Indeed, the Industrial Engineer must do this or be left in the backwash of progress as others take over the functions about which he has labored to build a profession.

It requires no great insight to comprehend this challenge for it has been at hand some years now in the "Operations Research" and "Management Science" movements. At the same time, it appears to me that these groups have been beset by internal confusions that have misguided many potentially productive efforts. I propose therefore that, irrespective of the names we use to identify our activities, there is a mutual challenge to all of us who are concerned with improving the technical knowledge and practice which supports the management planning and control functions. We need to approach this challenge in the spirit of an explorer, but also in the manner of a prudent one who keeps bearings on known landmarks. There have been earlier explorers and quite a few left their bones on the field. In fact, there have been organized parties in or near this field continuously for the past eighty years, and most of them perished.

There are only a few survivors left of the "Scientific Management" party, which came upon hard times because it understood too little of science. If misfortune comes upon the presently active "Management Science" group it will be, I predict, because it understood too little of management. Among some members of this group the "executive" has already slipped away into a dim abstraction—a little black box concept called "decision-maker." They appear to be concerned with the development of "decision-models" that will make the little black boxes work better; or, in more general terms, with the replacement of a feeble subjective decision-making process with a scientific hypothesis-testing type of process.

These explorers have already lost their bearings and we shall gain nothing by following them. To reach their position we must make the implicit assumption, which is both naive and conceitful, that the particular form of rationality that has proven effective in scientific endeavor is also the most appropriate for other human endeavors. Moreover, to account for the present state of affairs we would seem to need a further assumption that executives have not been sufficiently intelligent to appreciate this and must therefore be helped.

I find it more plausible to consider that a considerable amount of superior intelligence has been at work in the executive function. Perhaps it is a different kind of intelligence than "scientific" intelligence, but I doubt this. It has, however, been directed to different purposes and it has, I am convinced, developed rational concepts of operation that are particularly effective for these purposes.

SCIENTIFIC INQUIRY

Thus, what executives want of science is not an instruction in the virtues of scientific methodology but the applied results of scientific inquiry. To transfer this benefit an appreciation of the management function and its rationality is required. It is also necessary to restore discarded details in translating back from scientific generalizations in order that they may have suitable correspondence to a specific reality. This is precisely the function of engineering. To put it another way: the scientist who wants to be directly helpful to executives had better learn to "act like" an engineer. I use the phrase "act like" for the particular reason that it leads into the main line of my argument.

It is elementary to suggest that inquiry into the nature of the management function begins properly with observing the behavior of people who perform this function. If we also observe behavior in engineering and scientific activities and seek to identify the ways in which they differ, I believe we will be on the way to useful under-

* Based upon a presentation to the Management Control Systems Symposium, July 28-31, 1959, System Development Corporation, Santa Monica, California. (To be published by John Wiley and Sons, Inc., as a chapter of a book on management control systems.)

standing. I propose that when we do this sort of thing we will find some of the commonly presumed characteristics to be useless as differentiating variables. The subjectivity-objectivity contrast that is sometimes supposed to exist between executives and scientists appears unsupportable. Subjective judgments are found to be dominant in the creative phase of scientific activity. And if we discount the influence of exterior discipline imposed by international criticism of published work, it appears that scientists as a group are probably not more objective than executives.

BEHAVIOR CHARACTERISTICS

Some interesting and significant differentiations are possible, however, if we consider characteristics that I have called the "environment coupling of behavior" and the "time coupling" (see Figure 1). When we look at what a scientist does we find that the activity is directed toward abstraction from the specific environmental data of his research to the highest possible degree of generalization; and so we would say that in science there is a low degree of environment coupling. The broader the generalization the greater its scientific importance will be, and the lower the environment coupling. We would find also that the connection of the scientist's activities to deadlines is highly elastic. Perhaps the simplest definition we can give of pure science (a partial one, of course) is: no deadlines. So we would characterize scientific activity in the lower left of the "coupling" space, showing it to be low in both environment coupling and time coupling.

If we then look at engineering activities we find a higher degree of environment coupling. An engineer is not interested in thermodynamic theory as an abstraction. He is concerned with its particularization to the design of a specific power plant at a specific site to meet a peak power demand of so many kilowatts. He is also time-coupled to a higher degree than the scientist. He must have his plans ready on a certain date to go out for bid. Within that period he has some flexibility in the use of his time from day to day, but he must schedule toward the deadline.

The executive is highly environment coupled. He is concerned with influencing the crucial vote in his board of directors to win approval for investment in the new plant that his engineering staff is designing. In general, he takes the economic and physical particularizations worked out by his staff and to them adds the political, social, and individual specifics. He sets the engineer's plans into the action context. His appointment calendar suggests the high time coupling of the management function.

The apparently high degree of correlation between environment and time coupling suggests that there is a more fundamental connective idea which we have yet to explore. We have adopted a behavioral approach to consideration of the management, engineering, and scientific functions; and have found that the behavior differs in observable ways. Under the premise that the behavior is rational in each instance we are led to the premise that the differences arise because of differences in the basic objectives of the behavior. In short, managers, engineers, and scientists behave differently because they are trying to do fundamentally different things. What are these objectives?

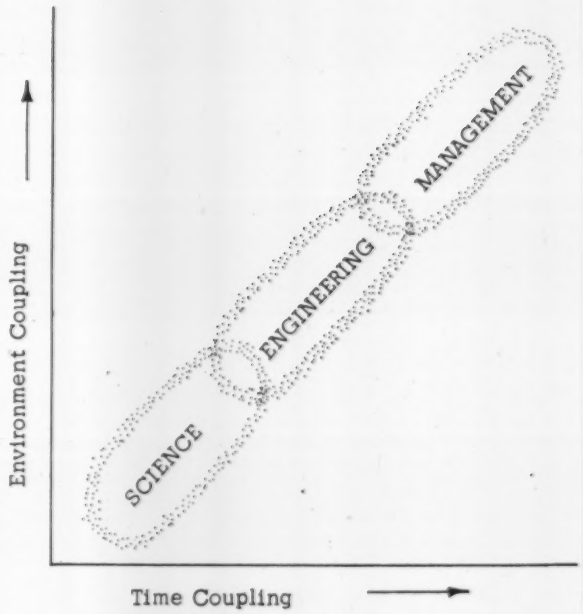

Fig. 1

THE FUNCTION OF SCIENCE

I find a satisfactory answer for "science" by tracing the word back to its Latin root—*scientia*—knowing. It is interesting, I think, that this is the present participle rather than the noun. It is a simple, elegant statement of a noble objective. It seems shameful that it should have been contaminated by so much sloppy usage in recent years. ("Applied Science" sounds a bit vacuous if one translates to "Applied Knowing.")

There are, of course, some special requirements for knowing as science, as against knowing in the usual sense. I mentioned previously the importance of subjective judgment in science. The whole progress of science depends, in fact, upon the willingness of men with great insight to announce conjectures on the basis of subjective validity. However, the rules of science prohibit the acceptance of any structure erected on conjectures until the formal objective processes have converted the conjecture into a scientific conclusion. In the case of some famous mathematical theorems it has taken hundreds of years for the formal processes to establish the validity of the original insight in an acceptable fashion. To make

matters worse, mathematicians occasionally decide to "tighten up" the rules and then some theorems have to be proven all over again. I make this remark to bring out the point that the formal objectivity of scientific activity is not an absolute concept but is defined by rules agreed upon by scientists in the field as being appropriate. Since rules are simply a means of sorting "good" ideas from "bad" ones, and since "good" ideas foster development of a field whereas "bad" ones inhibit it, we may conclude that appropriate rules are those which at any given time tend to maximize the progress of a science.

The obvious implication of this is that different fields of science may have different rules. And we can see clearly that the rules are in fact different on comparing the broad fields of mathematical, physical, biological, and behavioral sciences. There should be a very strong expectation, then, that other kinds of activities, such as engineering, have still different rules appropriate to their operations. And this also turns out to be true.

THE FUNCTION OF ENGINEERING

The function of engineering is the design or planning for solutions of particular problems. The rules which prescribe appropriate engineering behavior are markedly different from those of science. The difference is much greater than it seems to be in the popular, but erroneous, conception of engineering following along in the footsteps of scientific advances. In reality, the reverse is more often true. The accomplished engineering fact provides a powerful stimulus to scientific inquiry. James Watt's engines were already a commercial product and their designer was dead when Carnot formulated the beginnings of heat engine theory.

Engineering does not defer its progress until the ground ahead has been fully prepared by scientific inquiry. It moves whenever there is a practical need and when technical insight suggests that the chance of success is sufficiently good. And this insight, like scientific conjecture, typically surges ahead of the formal scientific development. Here, then, is another reason for saying that "applied science" is an inadequate term for engineering. This is not to deny the dependence of engineering on formal science. There is a limit to this "forward reaching" such that until scientific inquiry has built a foundation under the steps already taken, further engineering progress is increasingly inhibited.

The terminal product of a scientific inquiry is generally the published communication of results to the scientific community at large. The terminal product of engineering on the other hand is an implemented plan or design. We can imagine, then, that the mutual interactions between engineering and the management function must be equally important and far more personal than those with scientific activities. The mutuality of the interactions needs some special emphasis, for there seems to be a tendency toward the one-way flow conception. The dependence of engineering on science, for example, is quite widely accepted (if not understood); whereas the suggestion of a reverse flow of stimulus is often received as a novel idea (though it is not really obscure). I feel that there is a similar tendency among technical people to undervalue the usefulness of mutual interaction with management in enabling the engineering function to perform effectively. I sense something of this conception when I hear operations research people speaking of "problem solving *for* executives," but rarely mentioning how much of the total problem the executive had to solve. I wonder then whether there was effective interaction and, if not, how much more difficult was the executive's task for lack of it.

THE FUNCTION OF MANAGEMENT

If problem solution is defined as the accomplishment of a change in operating results the joint nature of the endeavor is inescapable. Technical knowledge must be joined to operational insights and appreciation of policy and other constraints. The executive role is again significant in the evaluation of alternatives because of the inability of formal methodology to get at the multidimensionality of "value." This, at least, is my present judgment for I have yet to see convincing evidence in the operations research literature or elsewhere that any of the formalistic devices for operating on lower order subjective judgments lead to better results than a subjective synthesis at the executive level.

This subjective synthesis is one of the crucial roles of management and I think it would help us a great deal in the development of improved technical support of management planning and control if we could learn more about it. I am persuaded that these endeavors will be successful to the extent of helping executives to increase effectiveness of the process. An infinite optimism would be required, however, to support anticipation of its replacement by a formalized methodology. I base this conviction on several considerations.

INTUITION AND RIGOR

There is first to be taken into account the power of intuitive processes. By these processes and with an algebraic notation that was clumsy in comparison to what was later available, Fermat arrived at some remarkable mathematical theorems. To reconstruct these theorems by formal processes so that they could be considered rigorously proved required a much greater volume of effort by some of the world's most skillful mathematicians. It is certainly true that the initial insights were not rigorously supported. For the purposes of mathematical science it was probably worth the expenditure of effort and passage of time (several hundred years) for some of these theorems to be proved. But the engineering and management functions have different purposes, and

there are other ways of buying the kind of pratical validity that is required. If a certain yet-to-be-proved theory should appear useful for the design of, say, a missile, the engineer uses it to design, build and test one. A successful flight might or might not be rigorous proof for correctness of the theory, but it would provide practical assurance that a missile designed and constructed in that particular way could fly.

The point has been made that formal methodology can buy rigor. It should be mentioned that this rigor is internal only. The mathematician can have optimum solutions, for the unequivocality implicit in the notion of "optimum" is established by internal rigor. It cannot assure against the "optimum solution" being a wrong answer when projected to an external application. Real management problems are external to mathematics. There are no optimum solutions to these problems because there are no unequivocal operations for defining them. Hence, to speak of practical solutions as "optimum" is to invite attention away from the equivocalities inherent in their development. The term is at best an inaccuracy, at worst a deceit.

The formalist has learned to keep himself happy by living within his axioms, and finding aesthetic pleasure in the pursuit of internal rigor. The engineer and executive must live with results. Competitive pressure to improve results works against the hope of raising assurance out of the subjective realm and, in fact, puts a premium on the sensitive feel for trade-off of assurance against time and effort.

All experience indicates that there is a trade-off as indicated by the heuristic equation:

$$R = f(T, E)$$

where R is rigor, T is time, and E is effort (perhaps roughly measured in dollars). It is impossible to make a decision without playing the trade-off. The scientist plays conservatively. The engineer will take less primary assurance, but usually buys some secondary assurance with a "safety factor" which is often cheaper. The executive must play aggressively without a safety factor. But he has in many instances the unique advantage that the effect of decision quality on the ultimate pay-off is considerably modified by other factors.

The executive who mischances to make only a fair decision but implements it skillfully and vigorously may still best the competitor who makes a superior decision but defaults on implementation. In fact, skill in selecting the superior alternative is probably of lesser importance than organization skill, a sense of decision timing, and an ability for vigorous implementation. A man with these talents can apply the resources of many more intellects than his own in accomplishing the selective act of decision making. He can, in other words, create a decision process to which he mainly contributes the timing and the "maintenance" effort to keep the process operating effectively.

PRACTICAL RESULTS

The suggestion is before us then that management is not a simple function, but is better described as a complex of functions requiring some rather impressive executive talents. The end objective of management is, of course, not simply the making of decisions nor even the making of good decisions, but the achievement of practical results. Managements are not judged on the number of decisions made, or on the quality distribution of decisions. Successful managements are rarely called to justify decisions, whereas failure generally forecloses explanation. Evaluation by results is the only sound principle, though in the application there is perhaps too great a tendency to emphasize present results with insufficient allowance for the expectation of future results arising from present actions taken under a long range plan.

The importance of long range planning is intensified by technological change and associated economic factors and this has been reflected, I think, in recent years by corporate organization changes and allocations of resources. While the general subject of long range planning is beyond our present interest, it is here that the interrelationships of scientific, engineering, and management functions can be seen in a useful perspective. It is a perspective from which we may wish to view our own activities as they on the one hand contribute to the process of change that presents management with its planning problems, and on the other contribute to their solution.

I shall refer to another diagram, Figure 2, which serves to illustrate some important relationships. I conceive of management in its operating role directing attention to maximizing the output of "existing solutions." Since I am not now concerned with current operating problems I show the existing solutions as static points. They are static in the "System Configuration" sense. The near future possibilities for improvement of results lie within what I have called the domain of technical, economic, and political feasibility. (I am using "political" in a broad sense to include internal constraints such as established corporate policy as well as external constraints such as work rule agreements, statute law, etc.) The majority of managers and engineers limit the search for improved operating results to the domain of current feasibility. But this domain has no permanent boundaries, and it is historically evident that the major increments of progress in productivity and the material well being of mankind come about through enlargement of the domain.

In providing for national military defense we have no choice but to press vigorously against technical feasibility barriers. In other matters of equal or greater im-

portance a similar vigor is needed in the reduction of politico-economic feasibility barriers. We have already established, for example, the technical feasibility of providing many peoples of the world a much better food supply than they now have. In reducing the politico-economic barriers to this achievement the skills and energies of executive leadership are now of obviously greater importance than the supporting technical contributions.

Because the reduction of technological barriers so often exposes politico-economic barriers that must also be removed there must be an emphasis and strengthening, I think, of the interaction between engineering and management activities. This observation is not limited to those public and private enterprises that are actually applying resources to expansion of the feasibility boundary. The impermanence of this boundary, in an era of increasing technological development, must be of concern to every enterprise. It is necessary to locate the boundary as well as possible and predict how it will shift so that near future plans will have what in military weapons development is called "growth potential."

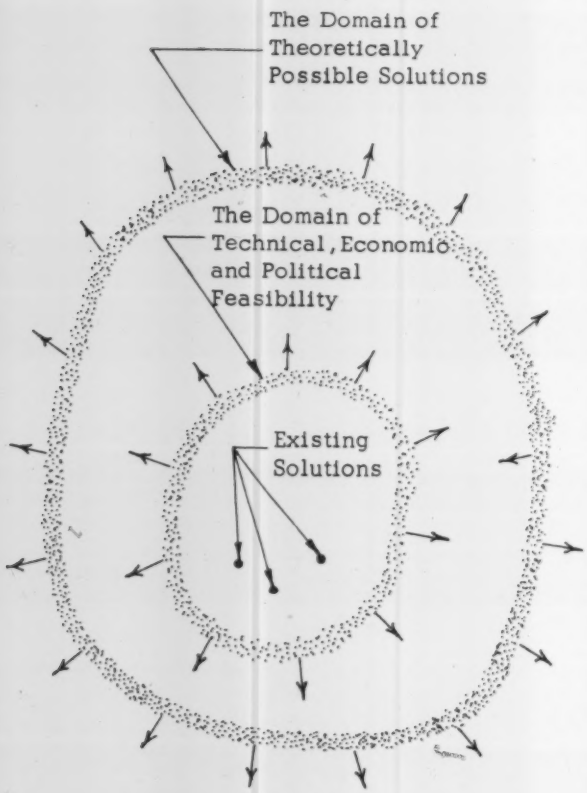

FIG. 2

POSSIBLE SOLUTIONS

Accordingly, we must look beyond the feasibility domain to the domain of theoretically possible solutions. The mapping of this domain is possible because of scientific activity. The actual formulation of possible solutions to specific practical problems is an engineering type of activity because the statements of scientific results appear as generalizations. We are speaking here of a creative engineering activity lying at the "near science" end of the engineering activity spectrum. There may well be more science-trained than engineering-trained people engaged in this activity, which is perhaps why many refer to it as "applied science."

The concern of science is with pushing out the boundary of this domain of theoretically possible solutions. It does this by conjecturing something beyond it and devising ways of testing the conjecture. It would appear then that long range planning operates in the region of possibility beyond current feasibility and that one of its special tasks is to take note of scientific advances and interpret their significance to the enterprise. Obviously, scientific advances have no significance for management except under an expectation of eventual feasibility.

It is often the easier part of long range planning to estimate the effects of scientific advances, assuming feasibility. (This is not quite the same thing as science fiction, which typically assumes both possibility and feasibility.) The usefulness of long range planning to management comes from identification of the technical, economic, and political barriers to feasibility; the estimation of time and effort for reduction of the barriers; and the development of specific courses of action for achieving and/or exploiting feasibility. Reliability of the results depends, even more than in other engineering activities, on personal competence, judgment, and sense of professional responsibility. There are no "handbooks" or standard formulae for long range planning.

SUMMARY

This then is the engineering function in long range planning. It supports the executive who, as chief planner, initiates the activity, commits resources to it, provides creative guidance in politico-economic considerations, and finally uses planning results to guide present management decisions according to their future consequences.

Long range planning, as we have described it here, is a relatively new concept for many executives and for many engineers as well. It is the outgrowth of the need for more effective response to the tightening challenge of technological competition. As the challenge will surely increase in coming years so will the development of this activity. There is opportunity here for the Industrial Engineer who points his professional development toward new horizons of the engineering function.

Toward a Theory of Scheduling[1]

by **ALAN J. ROWE**

Manager, Business Management Control Systems Research, System Development Corporation

SCHEDULING has long been recognized as an important factor in the effective utilization of limited manufacturing capacity. Attempts at solving the problem have either dealt with gross capacity considerations or the detail sequence in which parts are fabricated. Neither approach incorporates the interdependence of total capacity with detail machine scheduling, or the variability in factory performance due to fluctuating demand, unpredictable worker performance, unexpected machine delays, variable product quality, and queueing effects. Present industrial methods of scheduling provide arbitrary time allowances for successive machining operations in order to overcome the effect of these factors. However, arbitrary allowances often result in excess costs because of the expedients needed to carry out a given production program. As an alternative, scheduling decisions rules which take the stochastic aspects of the problem into account are proposed.

JOB SHOP PRODUCTION SYSTEM

A job lot production system is often characterized by its physical arrangement and operating modes. The equipment is typically general purpose and arranged by the type of work performed as contrasted with a flow shop where the machines are arranged to suit a specific product. The combination of set-up and run time is often higher in a job shop as a result of general purpose machines and individual lots. The mix of products is variable in quantity and type, and has a wide range of value as well. The variety affects both the inventory and queueing aspects of the problem. Manufacturing processing time is also typically more variable due to new tooling, complex instructions, and the large variety of work. In addition to the physical characteristics, other aspects of a production system include information flow, points of control, and operating decision rules. Although these factors are seldom formalized in actual practice, Figure 1 illustrates the typical flow of information and decision points in a production system.

Another consideration in describing a production system is the number of possible paths through which the jobs can flow. The exact sequence of the jobs is often referred to as scheduling. In the most general case, all jobs could follow all possible paths, that is, there would be $(N!)^m$ paths, where N is the number of machines and m is the number of machining operations through which a job must be processed. In actual practice, there are very few such jobs shops, since there is often a limited variety of products, and these generally follow a limited number of paths.

In view of the fact that even small scheduling problems are extremely difficult to formulate and solve in terms of all the variables, the complete enumeration of large-size scheduling problems is virtually impossible. For example, a shop having ten machines and ten jobs would have $(10!)^{10}$ possible job permutations, or approximately 10^{66} possible job assignments. Even if only 1 percent were feasible, these would constitute 10^{58} permutations, which is still prohibitive for enumeration. On the other hand, an alternate approach to considering various permutations is to maximize the expectation of applying given decision rules.

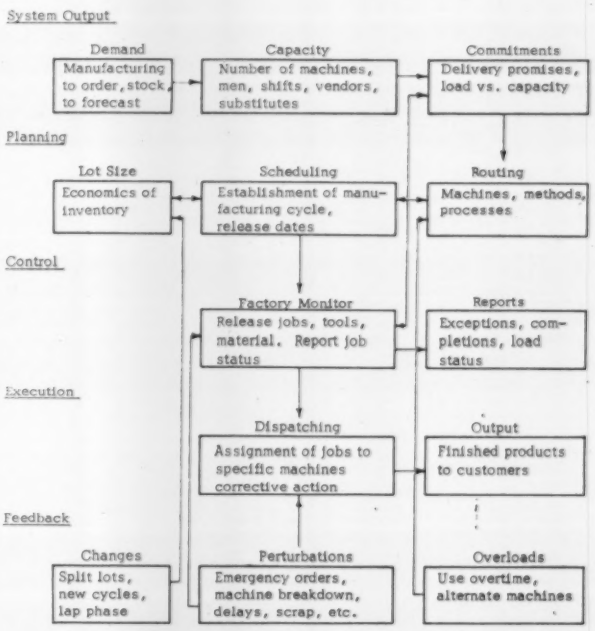

FIG. 1. Operating Characteristics of a Production System.

[1] The results reported here are based on a Doctoral Dissertation, submitted to the UCLA School of Engineering, under the chairmanship of Professor E. P. Coleman; and a computer simulation project at the General Electric Company, conducted in cooperation with the IBM Corporation.

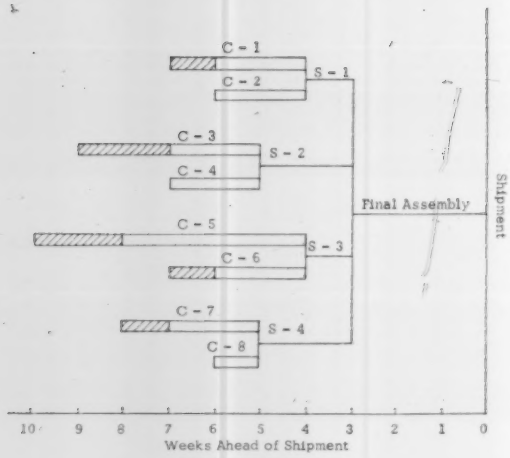

FIG. 2. Typical Time-Cycle Chart for Manufactured Items.

SEQUENTIAL SCHEDULING DECISIONS

The sequential approach to scheduling decisions establishes a basic plan prior to the execution of a given program and utilizes priority rules for the implementation of the program. Thus, rather than specifying the exact sequence in which jobs are to be performed, the initial scheduling phase establishes an overall manufacturing cycle for each component based on probabilistic methods (Figure 2). A variable flow allowance, which can be based on the value of the jobs, establishes both the manufacturing cycle and the release date of the jobs to be processed in the factory. In addition, each operation of a job has a specified start date within the manufacturing cycle (Figure 3). As work progresses through the factory, the planned start date is compared with the current date. A priority function which includes the deviation from start date is used as a basis for choosing which job to assign next. A number of alternate priority functions are examined later.

PARTITIONING SCHEDULING TO PERMIT SEQUENTIAL DECISIONS

Sequential decision rules require partitioning of the scheduling problem into three phases:

1. *Loading*—The comparison of the total hours of demand with the capacity for a given time period, not considering detail assignments of jobs.
2. *Scheduling*—Establishment of the manufacturing cycle which is used to assign demand to specific days within the time period.
3. *Dispatching*—The assignment of each job to specific machines at given times within the time period.

Loading, therefore, merely considers the total hours of work for a given time period, whereas scheduling establishes when each job is to be completed within the cycle. On the other hand, dispatching is often called the combinatorial scheduling problem, since the result is a matrix showing the exact sequence of jobs assigned during the given time period.

If the total hours of load for a given period exceeds capacity, normal operating rules cannot be applied to production scheduling. The practice in industry is to adjust capacity by working overtime, subcontracting, or extending delivery promises. With this approach, the overall load can be kept within acceptable limits. Once the overall load is kept within bounds, the problem of establishing manufacturing cycles and job assignment is still difficult. The "scheduled" load is assigned to specific work days by taking the start date for each operation and assigning the work to the appropriate machines. Although the work for a given job can be spread over the period, there may still be conflicts with other jobs having the same start date during the period. At this point, an exact sequence of jobs could be established; however, the manner in which jobs are actually completed often differs quite significantly from the planned arrangement. Decision rules which adjust the relative priority of jobs as they are actually processed rather than maintaining an arbitrary predetermined sequence therefore appear necessary.

In making decisions sequentially, there is an opportunity to take corrective action as the need arises. Upon examination of the initial planning phase of scheduling, it is evident that substantial improvements are possible. For example, if provision is made to combine similar jobs, set-up time can be appreciably reduced. Or, running the same job on several machines simultaneously will reduce the total manufacturing cycle time. However, in job lot manufacturing, the mix of orders to be processed varies considerably, thus making it difficult to plan the work completely in advance. The alternative is to plan the "flow" of each work order so as to permit the maximum flexibility in carrying out alternate activities. Since the flow of work orders determines their manufacturing cycle, the resultant manufacturing plan can be designed to meet given objectives.

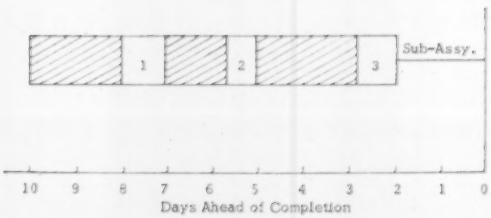
1
2
3
Sub-Assy.
10 9 8 7 6 5 4 3 2 1 0
Days Ahead of Completion
Day 10 - Order is released to the factory.
Day 7 - First operation is due to be completed.
Day 5 - Second operation is due to be completed.
Day 2 - Third operation is due to be completed.
Day 0 - Sub-assembly is due to be completed.
Cross hatch area represents transit and queueing time.
Blank area represents machining time.

FIG. 3. Manufacturing Cycle for a Given Component.

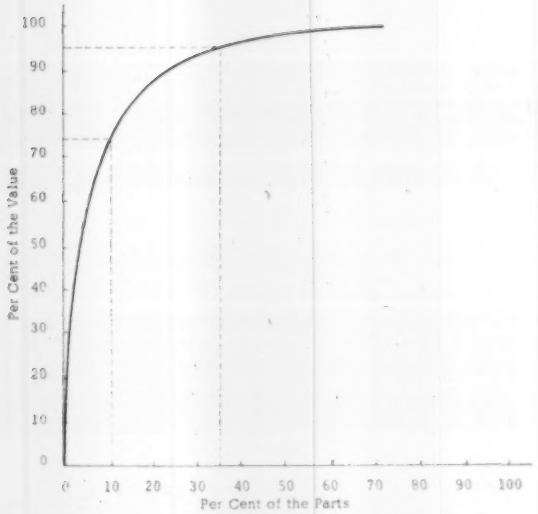

FIG. 4. Relation of Value of Parts to the Percentage of Items.

DEVELOPMENT OF SCHEDULING DECISION RULES

Scheduling, as defined earlier, establishes the manufacturing cycle time as well as the start date for each operation of each job. The cycle time consists of the processing, move, and delay allowance for each job. In order to minimize inventory, the delay which can be expressed as a flow allowance is made a function of the average delay at the machines, the value of the job, the number of operations and the loading factor. This flow allowance is used in the scheduling formula to compute the start date for each operation. The start date provides the basis for feedback control during dispatching. Where correct flow allowances are used to compute start dates for each operation of a job, it is possible to insure on-time completion. Rather than a single finish date to use as the basis for judging lateness, each operation then provides a bench mark which can be used to speed up or slow down the job.

Where the value of the jobs is disregarded, the flow allowance depends only on which machine groups the jobs were processed. However, in job shops there generally is a wide distribution of value of parts being processed, and potential reductions in work-in-process inventory are possible if a variable flow allowance is used. That is, the flow allowance would change continuously as the value of the jobs changed during processing. Thus, where raw material is cheap, but the labor added is high, a job could be released earlier than if the final value alone is used as the basis for the flow allowance. It would also permit distinguishing very high value jobs from lower value jobs in the high value category. An analysis of value categories for many typical factories made by H. F. Dickie revealed that there was a definite pattern (5), as shown in Figure 4. Reading from the curve, approximately 10 percent of the jobs constitute 75 percent of the total value of all jobs being processed. The percentages shown are typical; however, they would differ for any given product mix.

The flow allowance can be made inversely proportional to the value, as shown in Figure 5. One formulation for the flow allowance is

$$f_{ij} = k_j V_i^{-b}$$

where

k_j = a constant dependent upon the range of values at the jth machine group.
V_i = value of a given job at its ith operation.
b = an empirical constant.

The cost of carrying work-in-process inventory depends on the value of the job, the time in process, and the interest rate. Thus, by use of a "variable" flow allowance, it is possible to have less area under the curve for a given product mix than an "average" flow allowance. The carrying cost, for variable and fixed flow allowances, can be compared, as shown in Figure 6. The carrying cost, without interest, can be computed as follows

1. For fixed flow time

$$c = kV_i$$

where

k = average number of flow days for ith value category.

2. For variable flow allowance

$$c = KV_i^{1-b}$$

where

K = a function of job value, resulting in a variable flow rate.
b = an empirical constant.

Since the high value jobs are few in number, it is possible to decrease the time they spend in the shop, in exchange for increasing the corresponding time for the low value jobs, which should result in a net decrease in average value of work-in-process inventory. It is significant to note, however, that the total waiting time in the shop does not necessarily decrease; it is merely apportioned

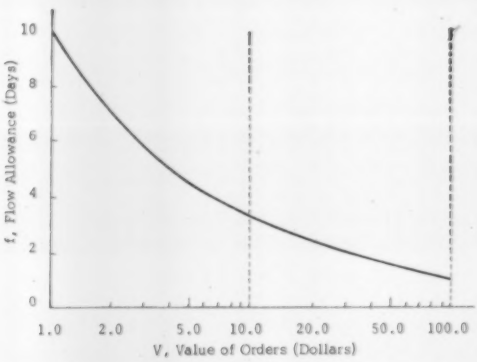

FIG. 5. Relation of Flow Allowance to Value of Job.

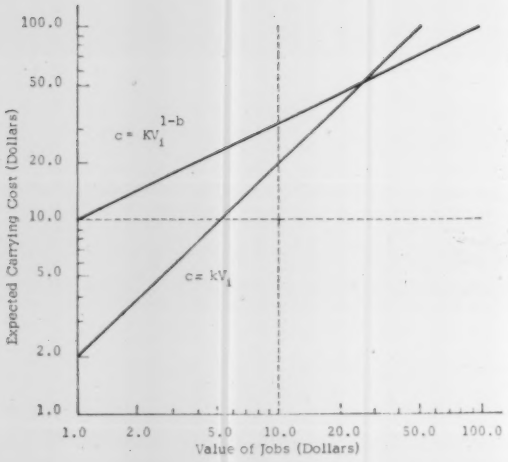

FIG. 6. Comparison of Carrying Costs Using Variable and Constant Flow Time.

in a more optimal manner for inventory purposes. Saaty, in his "Résumé of Useful Formulas in Queuing Theory," indicates that the expected waiting time is independent of queue discipline provided processing time is not considered (11). Where jobs having short processing time are given a high priority, Morse has shown that the expected total waiting time can be minimized (9).

Since the average investment in work-in-process inventory depends both on the time jobs spent in the shop and the rate of change of their value, the expected waiting is important. Thus, if the initial value of an order is high, rapid flow (minimum wait) through the shop reduces the expected total inventory value. Where the initial value is low, processing might increase the value substantially; therefore, as the value changes, the flow rate should be correspondingly increased permitting the flow rate to change continuously as the value of the jobs changes. However, there is a maximum flow rate possible (commensurate with meeting delivery commitments). On the other hand, decreasing the flow rate of the lower value jobs also has certain bounds. The cycle time cannot be increased beyond the limits which depend on normal delivery promises. In addition, releases which are too early increase the work-in-process inventory unnecessarily and cause difficulties due to schedule changes, obsolescence, and similar problems.

Another factor is used to compensate for jobs which have a high reject or rework rate. Time is added to the manufacturing cycle to replace or repair the parts. The total allowance then is

$$f \pm c \quad \text{or} \quad kV^{-b} \pm c$$

where f is the flow allowance for each operation. The critical allowance for the entire cycle, c, can be determined empirically.

The flow allowance is dependent upon the delay associated with each machine group. This delay, or queueing, represents the amount of time a job can expect to wait at a machine. If jobs are not removed from machines when a very high priority job arrives, there is an expected wait while the one on the machine is being completed. Rather than have all jobs wait an equal amount of time, priority classes can be established which distribute the expected waiting time in a manner designed to achieve a specified objective. Since minimizing the cost of assuring a specified completion distribution is one objective of scheduling, value of the jobs can be used as the basis for partitioning the queue time. However, not all jobs are processed through all machine centers; thus, the distribution of value at each center should be separately evaluated. Value categories were established for each machine group such that the upper 10 percent of the jobs were considered high value, the next 20 percent were considered medium value, while the remaining 70 percent were considered low value. With these percentages established the mean value for each category was determined. Using the functional relation

$$f = kV^{-b}$$

as the basis for the flow allowance, the waiting time for each value category was determined in the following manner: assume $b = 1$, then

$$f = \frac{k}{V}.$$

If f_h = the flow allowance for the high value category and f_m = the flow for the medium category, then

$$\frac{f_h}{f_m} = \frac{k/V_h}{k/V_m} = \frac{V_m}{V_h}.$$

Thus, the flow rates are inversely proportional to the values. If the value categories were continuous, this formulation would be adequate; however, for discrete values, the mean of each category is used to establish the flow allowance. Therefore, the following relationships are employed

$$f_h = \frac{f_m \overline{V}_m}{\overline{V}_h} = \frac{f_l \overline{V}_l}{\overline{V}_h}$$

where

$\overline{V}_l$ = mean value of the low category.
$\overline{V}_m$ = mean value of the medium category.
$\overline{V}_h$ = mean value of the high category.

If a suitable standard deviation is added to the mean delay, the following relation can be used

$$n(\bar{q} + kS) = n_h f_h + n_m f_m + n_l f_l$$

where

n = the total number of jobs processed at a given machine group.
$\bar{q}$ = the mean queueing time for a given machine group.
S = the standard deviation of waiting time for a given machine group.
k = the factor which assures a desired confidence level.
n_h = the number of high value jobs.
n_m = the number of medium value jobs.
n_l = the number of low value jobs.
f_h = flow allowance for high value jobs.
f_m = flow allowance for medium jobs.
f_l = flow allowance for low jobs.

This formulation assumes that

$$n = n_h + n_m + n_l.$$

Therefore, the following holds

$$\bar{q} + kS = \frac{n_h f_h}{n} + \frac{n_m f_m}{n} + \frac{n_l f_l}{n}$$

or, if

$$P_h = \frac{n_h}{n}, \qquad P_m = \frac{n_m}{n}, \qquad P_l = \frac{n_l}{n}$$

then

$$\bar{q} + kS = P_h f_h + P_m f_m + P_l f_l.$$

But, P is merely the percentage of jobs in each specific value category, which was established previously. Therefore, the P values are available to solve the equation. Expressing the flow allowances in terms of the high value category, the following relationship holds

$$\bar{q} + kS = P_h f_h + P_m f_h \frac{\overline{V}_h}{\overline{V}_m} + P_l f_h \frac{\overline{V}_h}{\overline{V}_l}$$

$$= f_h \left[P_h + P_m \frac{\overline{V}_h}{\overline{V}_m} + P_l \frac{\overline{V}_h}{\overline{V}_l} \right].$$

Since all the factors in the parentheses are known for a given machine group and product mix, the expression reduces to

$$\bar{q} + kS = K f_h.$$

Thus, once the mean delay and standard deviation are known, or estimated, the method for partitioning proceeds directly. This method was the one used as the basis for partitioning the flow allowance for the computer simulation runs described later.

If the mean waiting time is to be partitioned, the standard deviation is included prior to partitioning, rather than providing a separate standard deviation for each of the partitions. In this way, the total allowance at a machine group is reduced, at the same time assuring that the combined allowances are adequate to provide a desired confidence level. Although the variance at each machine station can be determined, the combined variance for all machines through which a job passes is more difficult to estimate. The total variance depends on which priority rule is used, since the deviation from the mean can be employed to alter the flow rates. Therefore, the total variance is a complex function dependent on the basis for job assignments, and the variability at each machine station.

A SCHEDULING DECISION RULE

Allowances, when added to the machining and transit time, establish the manufacturing cycle for each job. To determine the start date for each operation of a job, the following scheduling formula can be used:

$$S_i = D - \sum_{i}^{m} (P_i + t_{i-1}) - \sum_{i}^{m} (f_{ij} + \sigma) \pm C$$

where

S_i = planned start date for the ith operation.
D = promised delivery date for completion of the job.
P_i = processing time for the ith operation.
t_{i-1} = transit time from operation $i-1$ to i.
σ = cycle variance allowance for remaining number of operations from $i=m$ to n.
f_{ij} = flow allowance for operations $i=m$ to n based on value and the delay for the ith operation at the jth machine group.
C = cycle correction for critical jobs or special machine groups.

THE JOB ASSIGNMENT DECISION RULES

After the jobs are scheduled and released to the shop, another decision rule is required which will enforce the planned cycle time. Dispatchers use this rule to choose which job to assign when a machine becomes available for work. Sequential decision rules relate the scheduling allowances to actual performance in dispatching by using a priority index to compare the various jobs in a given queue awaiting assignment. The purpose of the priority index is to reduce the probability that a job will miss its due date and, therefore, ignores the value of a job, since a low value job can hold up shipment as well as a high value one.

There are many possible functional relations which can be used to establish a priority index. Since the flow time is determined during scheduling the sequential dispatching rule takes cognizance of a difference between actual time remaining prior to completion and planned flow time. As this difference increases, the priority of the job increases. The absolute difference, however, is not a sufficient measure of priority, since the number of operations or specific machines through which the part must be processed is also significant. For example, if two jobs have the same remaining flow time, but one has a larger

number of operations, it would have a higher priority since there is a higher probability of missing the due date for a larger number of remaining operations.

The time to process a job can also be considered as a basis for an assignment. This can be divided into the processing time for the operation under consideration and all other remaining operations for the specific job. If all other factors are equal, assigning the job with the shortest processing time for the current operation, as contrasted with remaining operations, will tend to reduce the total lateness of all jobs. For example, if one job has ten hours of processing and the other has one hundred, then assigning the shorter job causes the other to wait ten hours, whereas the converse assignment would cause the short job to wait one hundred hours. However, if provision has been made in the flow allowance for the short job to wait, this amounts to carrying out the schedule plan; although at some point, further waiting might cause the short job to be late. Thus, where flow time and number of remaining operations are equal, the processing time itself affects lateness.

A number of priority rules have been proposed as the basis for dispatching jobs in the factory: a priority based on the concept of "slack" has been proposed by Nelson (10) and Grad (6); a study to determine the effect of processing time on job completions was made by Jackson (7); the deviation from planned date as a priority was first proposed by Salveson (12); a two part rule used to sequence jobs so as to minimize set-up has been examined by Conway (4). Each of these investigations has attempted to find a decision rule which would lead to an optimum sequencing of jobs. Basically they have followed a probabilistic approach to solving the problem. Another approach has been proposed by Akers (1) and Barnes (2), using Boolean Algebra. However, an exact sequence or permutation in which jobs should be assigned would be difficult to carry out due to the highly variable nature of job shop production. It was this latter consideration which led to the sequential decision rule approach which uses expected flow rates for scheduling and job assignment. Another approach to the problem by Karush and Moody considers the overall factory load and assembly sequence as the basis for establishing feasible schedules (8). An excellent review of the various approaches to the scheduling problem is given by Sisson in his article, "Methods of Sequencing in Job Shops—A Review (13)."

A search technique, based on sampling of alternate assignments, could be used to determine which assignments tend to minimize the expected lateness. However, flow time can also be used to determine which jobs might become late at future operations. Having appropriate information, assignments can be made so as to permit more rapid flow of potentially late jobs. Dispatching rules, which assign a higher priority to jobs that might become late, tend to assure rapid flow. Normally, in dispatching, no attempt is made to control future operations. Dispatching is principally concerned with assigning jobs that are available in a given queue without explicitly considering other queues. Scheduling is presumed to have previously taken the overall loading into account, and provided appropriate flow allowances. Expediting can be used where there are potentially late jobs. For example, lot splitting, preemptive assignment, lap phasing, alternate sequencing, or alternate equipment could all be applied as special rules when the flow time has been exhausted. Dispatching rules, therefore, can be designed to work effectively under normal operating conditions, and when special problems arise, expediting rules could be substituted.

Although many rules have been proposed for use in dispatching, at present, no analytic formulation has been made which assures optimality. The rules presented here for use in conjunction with the scheduling formula previously described are primarily a logical approach to sequential decision making.

A rule which has been tested on many problems and has led to good solutions is based on the planned flow allowance established during scheduling. This formula for establishing a priority index is

$$\Pi_i = \frac{(T - S_i) - A_i}{N^{\pm b}}$$

where

Π_i = the priority index for a given job at the ith operation.
T = the fiscal day number when the index is being compared.
S_i = planned start date for the ith operation.
A_i = a factor which is based on the flow allowances established during scheduling.
N = the number of operations remaining from i to m.
b = an empirically determined constant.

The job with the largest algebraic priority index is assigned to a machine when there is more than one job competing. The deviation from start date, $(T - S_i)$, provides a measure of the lost time as a result of waiting for assignment or late delivery. When this deviation is compared with the flow allowance, A_i, it indicates residual time. Thus, when $T - S_i - A_i$ is positive, it indicates that the job has exhausted its current flow time. A modification of this rule is to have A_i only include the flow time for the ith operation; thus, the job would not necessarily be late when the quantity is positive.

The residual flow time, $T - S_i - A_i$, is divided by the number of remaining operations when the job is early. That is, the constant, b, is made positive. If the residual time is positive, the constant, b, is made negative, which results in multiplication by the number of operations. An alternate to dividing the residual flow time by the num-

ber of remaining operations is to divide by the expected remaining waiting time.[2]

Another form of priority rule explicitly incorporates processing time as one of the factors. One such formulation follows

$$\Pi_i = (\Delta)^k + \frac{N^b \sum_{i+1}^{m} P_i}{\sum_{i+1}^{m} P_i + \sum_{i}^{m} a_i - \Delta}$$

where

Π_i = the priority index for a given job at the ith operation.

Δ = deviation from planned start date, $(T - S_i)$.

k = an empirically determined constant.

a_i = the flow allowance for the ith operation only.

N = number of remaining operations not including the ith operation.

b = an empirically determined constant.

$\sum_{i+1}^{m} P_i$ = the remaining processing time, not including the ith operation.

$\sum_{i}^{m} a_i$ = the remaining flow allowances for operations from i to m.

This formulation of the priority index treats the deviation from start date as compared to flow allowances for the current operation and for remaining operations. This rule attempts to assign jobs so as to minimize the probability of lateness. For example, if all other factors are equal, the priority rule will choose the job with a minimum a_i for the current operation. Where everything else is equal, the rule will choose the job with the largest number of remaining operations or it will choose the one with the most remaining processing time compared to the flow allowances. A rule, such as this latter one, would have to be run on a computer since it is unreasonable to expect a dispatcher to compute the priority index for every job assignment. An interesting variant of this rule is the following

$$\Pi_i = \left(\frac{\Delta}{a_i}\right)^k + N^{-b} \sum_{i+1}^{m} P_i \exp\left(\frac{\Delta}{\sum a_i}\right)$$

where all the terms are the same as before except that e is the base of the natural logarithm. This latter formulation places increased emphasis on future operations and correctly computes Π even though Δ changes sign. The prior formulation assumes that $\sum P_i + \sum a_i \geq \Delta$, so that the correct index is assigned. The characteristic form of the three rules is shown in Figures 7 and 8.

[2] This was suggested during a discussion of priority rules by R. T. Nelson, Staff Member, Management Sciences Research Project, UCLA.

THE USE OF COMPUTER SIMULATION

Simulation is an attempt to imitate the behavior of a system to study its reaction to specific changes. The results permit one to gain insights, test hypotheses, demonstrate or verify new ideas, establish feasibility, compare alternatives, design complex systems, or train personnel. Computer simulation, however, is seldom an exact analogue of the operation of an actual system. Rather, the majority of simulations are performed on digital computers which can only approximate continuous, simultaneous activity. If the elements and properties of the system have been properly defined, then the parameters and variables can be readily controlled and measured.

To simulate factory operations, then, it is necessary to have a model which provides a formal statement of the system behavior. This model may be a symbolic model, a mathematical model, or merely a descriptive model. The model should be constructed so that the parameters, variables, and forcing functions correspond to the actual system. The parameters should include properties which are sufficient to define the behavior of the system, whereas the variables are the quantities which describe the behavior for a given set of parameters. The forcing function provides the stimulus, external to the system, which causes the system to react. For example, job orders which enter the production system cause men to work, machines to run, queues to form, etc. In this way, job orders become the forcing function for the system. Whatever particular form is used, a model provides the frame of reference within which the problem is considered.

The design aspect of the problem can be accomplished either by modifying the parameters of the model and examining the behavior of the system or by specifying a given design and examining behavior under varying conditions. The first type of simulation is exploratory in that the new design will result from information obtained by simulation. The second type is a form of statistical sampling. That is, a given design is subjected to many conditions in order to determine its suitability. The latter has been referred to as Monte Carlo sampling. Monte Carlo

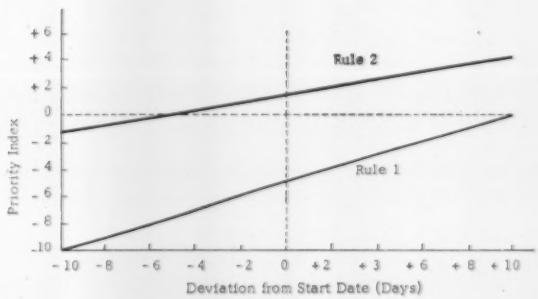

FIG. 7. Comparison of Alternate Priority Rules.

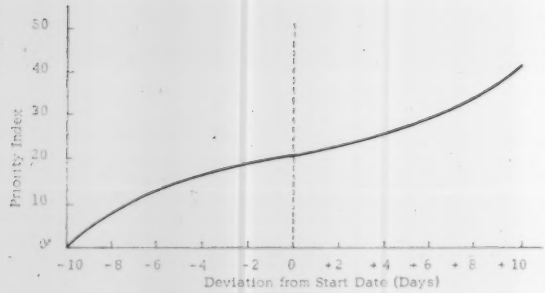

FIG. 8. Accelerating Priority Rules.

sampling is defined by Brown as "any procedure which involves the use of statistical sampling techniques to approximate the solution of a mathematical or physical problem (3)." Although there is no known distribution for scheduling type combinatorial problems, Monte Carlo sampling seems to offer a basis for comparing various decision rules. Non-parametric methods, such as lower or upper bounds, can also be used to evaluate the results. A lower bound to the scheduling problem, for example, is obtained from the comparison of demand and capacity. The total time required to process a given demand can be determined for each machine type, since the sequence in which parts are to be processed is not considered. This could be used for comparing the effectiveness of a given set of decision rules.

AN EXPERIMENTAL SIMULATION[3]

The simulation runs described in this section were based on a model of an actual job shop. The shop had 17 machine groups with a total of 85 machines. Each group consisted of a similar set of machine tools. This shop was chosen as being representative of the many complex problems encountered in job shop operations. There were large planer-milling machines, precision Blanchard grinders, multiple spindle drill presses, etc. The work processed in the shop consisted of a variety of orders, different lot quantities, small as well as large pieces, expensive and inexpensive items. The job processing time per operation ranged from a fraction of an hour to several weeks.

Certain simplifying assumptions were made in order to have a reasonable computer model. No lot splitting was permitted, nor was a job removed from a machine for a new job. Set-up jobs, although not torn down for high priority jobs, were not necessarily run if an idle machine was available for a higher priority job. Lap phasing, alternate sequencing, overtime, subcontracting, and expediting measures were not explicitly tested.

The priority rules used for job assignments in the experiment represent rules described in the literature or used in industry. The rules tested included the following:

1. First come, first served.
2. First come, first served within priority class.
3. Sequential rule.
4. Minimum imminent processing time.
5. Maximum imminent processing time.
6. Earliest start date.

Although many other possible priority rules exist, this experiment was meant to be representative rather than an exhaustive test of all possible rules.

The first-come-first-served rule is one of the classical rules in queueing theory. Applying this rule, the job which arrives first in a queue is given an absolute priority regardless of any other considerations. Arrivals at toll booths and at computers generally apply this rule. The three-pocket dispatching system of production control is essentially a first-come-first-served rule. A variation of this rule is the use of arbitrary priority classifications in conjunction with the time of arrival. Since inventory considerations are an important aspect of the scheduling problem, the value of jobs was used in the second rule as the basis for priority. Three value classes were used: high, medium, and low. The rule consists of choosing the first high value job which arrived. After all high value jobs have been served, the medium value jobs are taken next, based on the time of their arrival. Finally, the low value jobs are assigned. This rule, as well as all the others, is non-preemptive since, once a job is running, it is not torn down for a higher priority job. However, when a machine becomes available for new work, the higher priority class takes precedence, regardless of when any of the other jobs arrived. The latter rule is interesting in that it indicates potential inventory reductions resulting from the use of value classifications as the basis for the flow allowance.

The third rule takes the flow allowance into consideration, as compared with elapsed waiting time and number of remaining operations. Since the flow allowance is a function of value, this rule indirectly takes inventory into consideration. The number of remaining operations is indicative of the amount of processing still to be completed. In this way, the sequential rule attempts to maintain a high probability of on-time completion. There are a number of possible variations of the sequential rule which are related to the method scheduling. The particular form tested here is merely indicative of results using this approach.

The minimum-imminent-processing-time rule has been mentioned as being useful in reducing the total expected waiting time. In actual practice this is a "sneak in" rule where the short jobs are processed first, since they do not appreciably affect the waiting time of other jobs. The converse rule uses the maximum imminent processing time as a basis for assignment. Where there is a high correlation with value, the latter rule is very similar to

[3] The computer program for this simulation was written for the IBM 704 by I. Rezucha, Data Processing Division, IBM Corporation.

first-come-first-served-by-value category. The basic premise behind the maximum processing time rule is that by completing the long jobs first there is a smaller probability of late completion. In actual practice, high value jobs with long processing time are often given the longest lead times. In effect, this is a form of safety allowance so that if a part is scrapped there is sufficient time to replace it and still meet delivery commitments.

The start-date rule is the most prevalent in industry today. In effect, this rule assigns a planned date on which the job should start in order to be completed on time. The start date is typically determined by multiplying the number of operations through which a job must pass by an arbitrary allowance. This rule does not consider value of the job, time of arrival into the queue, nor processing time as the basis for assignment. The job in a queue which has the earliest start date is assigned first. The sequential rule also employs a start date; however, time of arrival in the queue, value, and processing are all used as a basis for assignment.

A slight variant of the start-date rule is to specify the due date of each operation. Often the due date for the final operation is the only one shown; however, this does not provide a satisfactory degree of control. Since the start-date rule is currently practiced in industry, the implementation of a sequential rule would be readily facilitated.

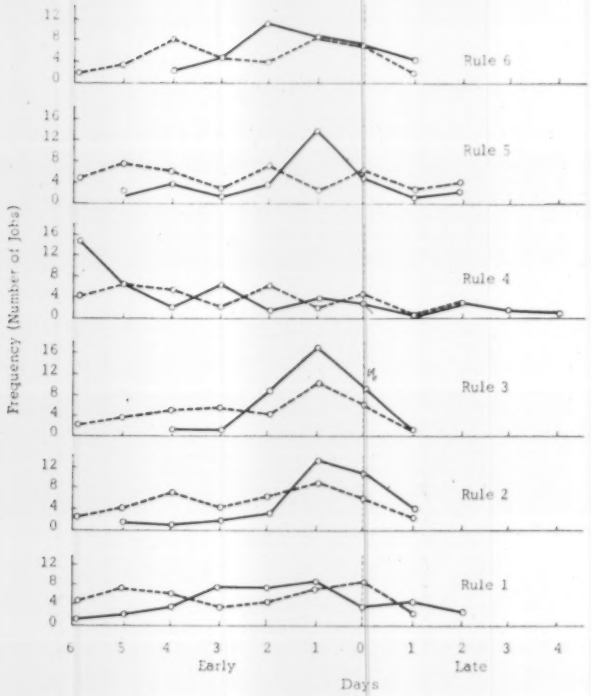

FIG. 9. Typical Distribution of Job Completions for Alternate Priority Rules.

TABLE 1

Mean Delay as a Function of Priority Rule

Machine No.	Load %	No. of Machines	Mean Waiting Time (days)				
			Rule No. 1	Rule No. 2	Rule No. 3	Rule No. 4	Rule No. 5
1	30.5	1	0.1	0.2	0.2	0.2	0.1
2	38.0	9	1.5	1.4	1.9	1.2	2.4
3	44.8	4	0.4	0.5	0.7	0.5	0.6
4	49.8	4	0.5	0.5	0.6	0.4	0.4
5	32.2	5	0.0	0.0	0.0	0.0	0.0
6	163.1	4	3.5	3.5	3.7	3.0	3.6
7	100.9	8	6.5	9.0	8.1	6.3	6.6
8	54.9	21	0.5	0.3	0.4	0.5	0.4
9	62.1	2	0.8	0.7	0.8	1.0	0.8
10	56.0	3	1.0	1.5	1.1	1.1	1.2
11	49.8	7	0.5	0.5	0.4	0.5	0.5
12	46.4	2	0.2	0.2	0.3	0.2	0.3
13	63.5	2	0.5	0.8	0.6	0.5	0.6
14	88.1	2	2.5	1.6	2.1	1.7	3.4
15	105.1	2	5.0	4.2	4.4	3.1	6.9
16	88.6	5	3.2	2.3	3.2	2.1	2.7
17	48.1	4	0.9	1.4	1.6	0.7	2.1
Total	60.6	85	27.6	28.7	29.8	23.1	32.6

ANALYSIS OF THE SIMULATION RUNS

The distributions of job completions for a typical run of simulated shop performance are shown in Figure 9. Two different load conditions applying the six priority rules were tested. The solid line represents a heavy load and the dashed line a light load. In addition to the mean completion, the skewness and range should be considered. In order that the number of jobs late be minimal a high negative skewness is desirable. This places the modal point of the distribution at or near the minimum deviation from due date. The shape of the distribution also assumes importance when one attempts to minimize carrying costs.

An analysis of these runs indicates that the distributions do not change radically for the conditions tested. A true Monte Carlo sampling, however, would require extensive runs to find the distribution of completions under many different conditions. The shape of the distributions, however, tends to change with the load. Maximum variability is found for the medium load, indicating that the allowances were too large for this condition. The difference among distributions appears most significant at the heavier load.

The mean waiting time was used to compute the waiting allowance for each value category. However, as was discussed previously, under certain conditions the mean waiting time depends upon the priority rule. A test run was made to determine experimentally whether the mean delay would be a minimum for the shortest-imminent-processing-time priority rule. Using actual shop data as the input, the results are summarized in Table 1. The number of machines and percentage of load are shown separately for each machine group. The mean waiting time in days is shown for each priority rule. Since the load and number of machines differ for each group, the data cannot be considered as samples from a single popu-

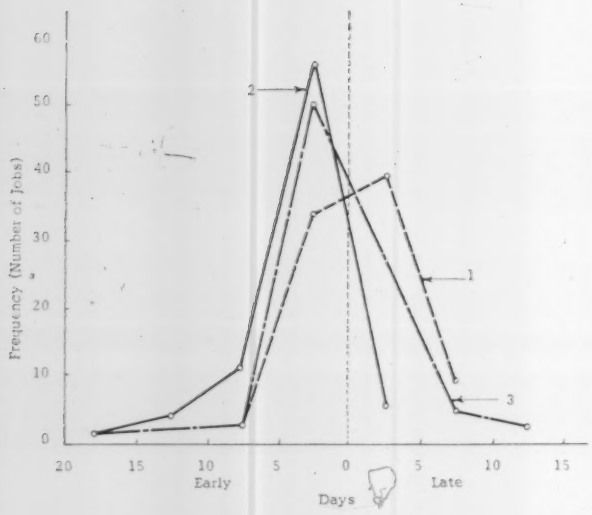

FIG. 10. Comparison of Completion Distributions.

lation. The aggregate waiting time for the system, however, could be treated as a sample from a given population. Since there was no replication of the individual rules, there is no estimate of their variance. Therefore, to test the hypothesis that the aggregate mean waiting time for the prority rule using the minimum imminent processing time differs significantly from the mean of the population, the Students t test was used. The results indicate that there is a statistical difference in the mean waiting time for this rule from the other rules assuming this simulation run as a representative sample. This rule could therefore be employed where minimizing the waiting time is a primary objective. Scheduling for computers often utilizes this rule, since in this way the waiting time of programmers is reduced.

To establish the basis for the flow allowance, another test run was made. The mean waiting time does not provide adequate assurance of meeting a desired percent of completions. If the waiting time distribution is Poisson, then there is approximately 90 percent assurance that the wait will be less than the mean plus one standard deviation. To determine the effect of flow allowances on the distribution of completions, three runs were made with the sequential priority rule. The first run used the mean waiting time for each machine group as the basis for assigning allowances. The second run used the mean plus one standard deviation (assuming a Poisson distribution). The third run used the mean waiting time for the entire shop as a uniform allowance for each machine group. The simulated factory load was approximately 80 percent of capacity. Figure 10 shows a comparison of the job completion distributions for the conditions tested.

Where the allowance included one standard deviation (Run No. 2), only 7.6 percent of the jobs were late. Using a variable delay at each machine group as the allowance, without the standard deviation (Run No. 1), 56.6 percent of the jobs were late. In Run No. 3, using a single grand mean as a uniform allowance, 39.1 percent of the jobs were late. It is thus apparent that the flow allowance should provide for variability. The number of standard deviations to add to the mean depends both on the density function and the desired confidence level.

A test was made to determine the effect of changing the value categories. As can be seen from Figure 11, the minimum cost occurs approximately at the division of 30 percent high value and 70 percent low value jobs. A separate run was made with three value categories. In this run the categories were 67 percent low, 23 percent medium, and 10 percent high value. The results of this run produced a cost of 337,000 dollar-days of work-in-process inventory, as compared to 342,300 for the two category classification. Thus, there appears to be a minimum carrying cost which is a function of the percent of jobs in each value category.

A comparison of four priority rules was made with fixed and variable flow allowances. Rules 1, 2, 3, and 6 were run with a fixed allowance of ½ day per operation. A second run was made applying the partitioning principle for value categories described previously. The results of these two runs are shown in Table 2.

An examination of the data reveals a number of interesting facts. For example, note that there was no change from Run No. 1 to No. 2 for the first two priority rules except for the completions which were improved in both cases. On the other hand, the second two rules improved both in carrying cost and completions. The latter improvement can be attributed in part to the fact that the second two rules tend to enforce the planned waiting allowances, whereas the first-come-first-served rules

TABLE 2

Comparison of Fixed and Variable Flow Allowances

Priority Rule	First Come, First Served		First Served By Value		Sequential Rule		Start Date Rule	
	Run 1	Run 2	Run 1	Run 2	Run 1	Run 2	Run 1	Run 2
Utilized Capacity	88.9	88.9	89.1	89.1	88.4	89.7	88.6	89.1
Wait Time High Value Jobs	0.75	0.75	0.10	0.10	0.58	0.12	0.66	0.22
Wait Time Medium Value Jobs	0.73	0.73	0.15	0.15	0.55	0.22	0.64	0.34
Wait Time Low Value Jobs	0.72	0.72	0.92	0.92	0.56	1.04	0.66	0.97
Wait Time Total	0.73	0.73	0.64	0.64	0.56	0.74	0.66	0.73
Dollar-Days Carrying Cost	538	538	338	338	457	389	516	414
Cost Ratio	89.6	89.6	82.4	82.4	87.7	84.7	89.1	85.9
Percentage of Jobs Late	42.2	14.7	31.7	5.0	31.3	0.0	54.2	4.0
Mean Completion	−.61	3.27	−.12	3.59	−.16	2.68	−.56	2.91

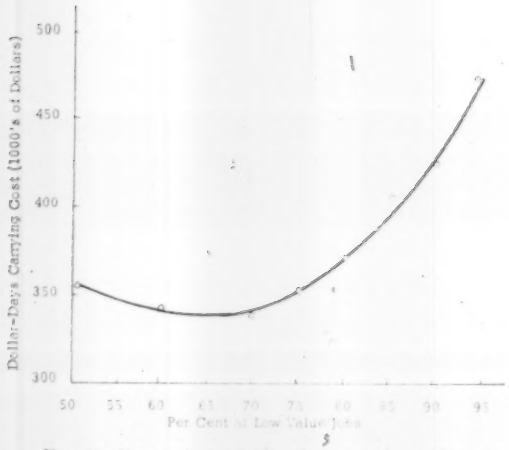

FIG. 11. Comparison of Carrying Cost for Different Value Categories.

tend to have waiting times which are independent of the supplied allowances. This is evidenced by the fact that the waiting time remained unchanged for the first two rules despite a radical change in the allowances. The partitioning of waiting time based on value was most effective for the sequential rule. For example, the percentage completions on time and mean completion are best for the sequential rule in Run No. 2. In addition, the variance of the distribution of job completions was a minimum for both runs with rule three. Different methods of assigning waiting allowances might also improve the other priority rules.

As a final test, the sequential-priority rule was run with different waiting allowances in an attempt to minimize the variance and carrying costs. The runs include the two previous ones just described in addition to two others. The summary of the four runs is shown in Table 3. The primary difference among runs was the change in planned flow allowances. The first run had a ½-day allowance per operation; the second had 1.4-days allowance; the third had a variable allowance based on value category and machine group; the fourth run used feedback from the simulation to correct the previous allowances.

As can be seen, there is a considerable improvement in the last run. Although the second run had all jobs completed on time, the carrying cost of 566,100 dollar-days cost is the highest in these runs. The variable allowance achieved equally good completions, and in addition a reduced carrying cost of 388,800 dollar-days or a 31 percent lower cost. The last run shifted the mean completion closer to zero, as well as achieving a further reduction in carrying cost.

It is apparent from these last runs that the correct allowances not only insure good completion distributions, but also reduced carrying costs. Thus, applying the partitioning principles to establish waiting allowances and using a priority rule to enforce the flow rates appear to provide a suitable method for scheduling jobs where there are competing demands for scarce resources and high variability.

CONCLUSION AND SUMMARY

The behavior of a job lot production system is extremely complex and determination of optimal decision rules is a difficult problem. The present study was concerned with evaluating the applicability of sequential decision rules to the scheduling problem. Decision rules which are based on the value of parts being processed appear to provide reduced costs while still assuring a desired completion level. A variable flow allowance is obtained by partitioning the mean queue time for each specific machine group. The flow allowance was made inversely proportional to value. Thus, by increasing the flow rate of high value jobs, inventory costs were minimized. To insure that the planned flow rates would be carried out, a priority queue discipline was established based on correcting for deviations from the planned flow. In this way, decisions were made sequentially rather than attempting to predict the precise job assignment permutation.

The variable flow rate can also be applied where value is not important. In this instance, there would be no partitioning of the mean waiting time, but rather the waiting allowance would be based solely on which machine groups the jobs were to be processed. Where there is a wide range of variability in machine utilization, there is a concommitant wide range of waiting time. Where this condition prevails, supplying a uniform waiting allowance for all jobs does not provide suitable confidence levels for insuring on-time completions and results in excess carrying

TABLE 3

Effect of Changing the Flow Allowance

(Priority Rule No. 3)	Run 1	Run 2	Run 3	Run 4
Utilized Capacity	88.4	91.1	89.7	89.5
Queue Time High Value Jobs	0.58	0.84	0.12	0.12
Queue Time Medium Value Jobs	0.55	0.72	0.22	0.21
Queue Time Low Value Jobs	0.56	0.70	1.04	0.96
Queue Time Total	0.56	0.72	0.74	0.68
Dollar-Days Carrying Cost	456.6	556.1	388.8	366.8
Cost Ratio Queue to Total	87.7	90.0	84.7	83.9
Percentage of Jobs Completed on Time	68.7	100.0	100.0	99.7
Mean Completion Days	−0.16	2.68	2.68	1.68

costs. On the other hand, the variable flow rate can be used to achieve improved performance where there is variability in mean waiting time from one machine group to another. However, to implement the variable flow rate, a priority rule is required which considers the rate specified.

Monte Carlo simulation was used to evaluate the sequential rules under various shop conditions. This approach appears to provide an extremely flexible means for studying the behavior of complex systems where analytical formulations are not available. Statistical experiments can be carried out, including replication, which would otherwise be impossible directly in the factory. Computer simulation also provides a means for evaluating some of the interdependencies in a production system, for example, determination of the correct balance of productive capacity with inventories resulting from queueing and customers service requirements. Factory layout, type of equipment, flow rates, single vs. multichannel service centers, could be easily evaluated. Location, type, and size of buffer inventories could be established. Correct lot size in relation to productive capacity, queueing, and alternate flow paths could be evaluated. The significance of variability in time standards could be determined in relation to the planning and execution of a production program. Simulation could assist in these and many other problems still requiring further research.

Probably one of the most fascinating aspects of simulation is the possibility of direct application to factory control. When new products are manufactured, or the mix changes, the impact on factory facilities could quickly and accurately be evaluated. Decision rules could be tested continuously to determine their suitability. The computer provides a laboratory where complex production problems can be examined. A better understanding of the behavior of production systems will lead to improved decision rules. The present research has demonstrated that computer simulation and Monte Carlo sampling are powerful methods for the evaluation of production decision rules. Futher research with these tools will undoubtedly yield considerable insight and theory on which to base optimal production systems design, much as mechanical, electrical, and other systems are now designed.

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president's message

by **FRANK J. JOHNSON**

President of the American Institute of Industrial Engineers, 1959-60

Organization for the Challenging Sixties

IN ANY organization, whether it be business, church or professional society, constant study of its operating structure is always desirable, particularly when it is young, dynamic and growing rapidly. As all of you know, the American Institute of Industrial Engineers has only been in existence for eleven years. In this period we have enjoyed an almost unbelievable growth, resulting in, as we could expect, some "growing pains."

During the past three or four years, many changes have been required in our organization structure and it has generally kept pace with our growth. Only last year we were forced to increase from six to ten regions. However, during the past year more and more problems have been brought to the attention of the Vice Presidents by the membership throughout the various regions. As a result of this "feedback" it became apparent that a thorough look at our organization structure was in order, not only to correct some of the current problems but also to place us in a position to meet many of the new problems which will be created during the next few years.

Last spring it was evident that we should go ahead with a complete study of the national organization. Your president, with the concurrence of the Executive Committee, appointed Mr. Jack F. Jericho, our National First Vice President, to chair a special committee to study this problem. He selected a committee consisting of the following well-known members:

Warren E. Alberts, Board Member-at-Large
George H. Gustat, Immediate Past President
Alex W. Rathe, Chairman, Professional Relations Committee
Andrew Schultz, Jr., Director of Research
Floyd J. Titler, Executive Secretary
William J. Vallette, Vice President, Region I
Raymond Villers, Chairman, Organization Planning and Research Committee.

These gentlemen first isolated the major problems which existed in our present organization. Some of the most important follow:

1. Chapter cognizance regarding activities being carried on by the national officers and committees was inadequate.
2. There was considerable overlap of project work within the various national committees.
3. A minimum of continuity existed as regards the Executive Committee, the Board of Trustees and the national officers.
4. Control procedures existed with little or no enforcement powers.
5. There was an inconsistency of dates, such as the term of office for national officers and national directors. (May for officers; October for directors.)
6. Little or no representation in the area of professional advancement and long range planning existed on the Executive Committee and the Board of Trustees.
7. Too many functions reported to the President and to the First Vice President, making it very difficult for these functions to receive adequate coordination and leadership from the top officers of the Institute.
8. The organization did not provide for a committee on conditions of practice and ethics for Industrial Engineering.
9. No central bureau existed where the chapters could go for assistance in selecting top professional speakers who were qualified in the technical aspects of Industrial Engineering for use at chapter meetings and conferences of any type.

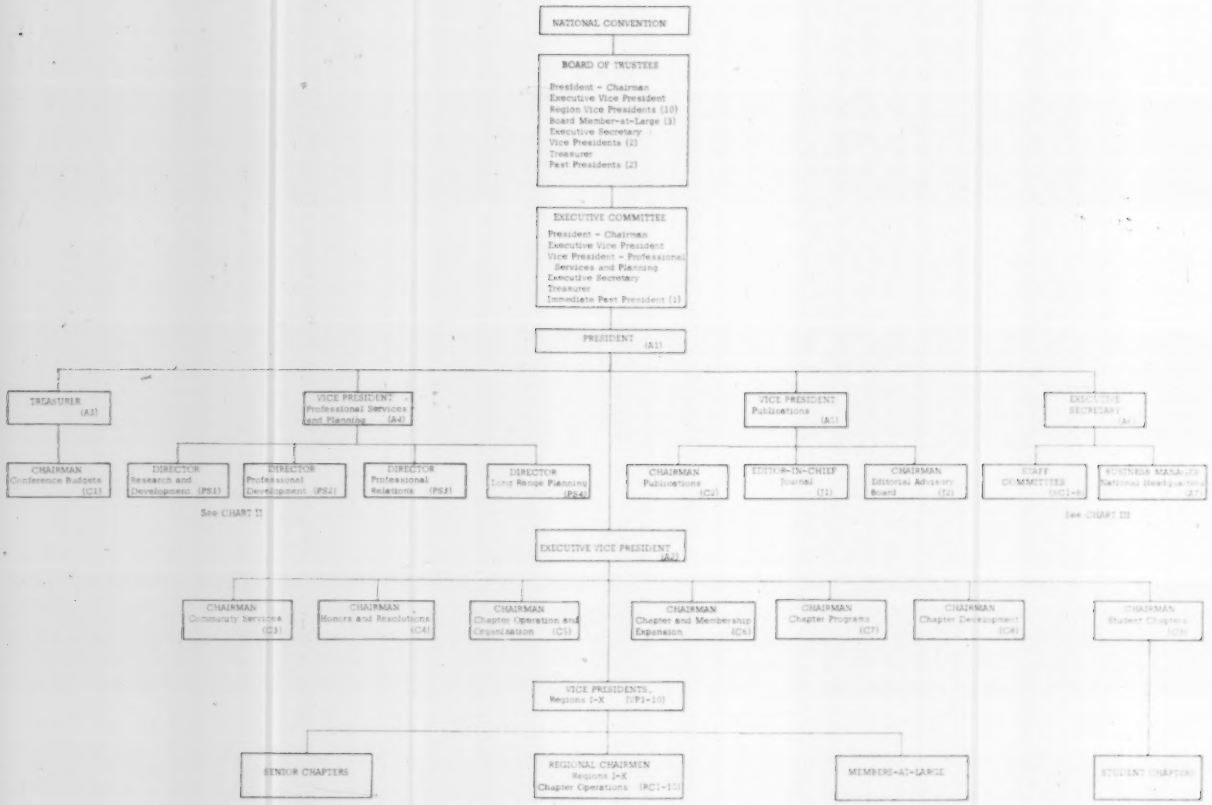

FIG. 1. American Institute of Industrial Engineers, Inc. National Organization Chart.

Several proposals were developed, taking into consideration the ideas from all committee members. These proposals were presented to the Board of Trustees at the October 17, 1959 meeting and with some minor changes the basic plan of re-organization was adopted. A copy of the new organization charts are shown in Figure 1 and Figure 2. Pending approval by the membership of the Constitution changes which are required as a result of this new plan, the organization will go into effect with the 1960-61 administration. While no organization structure can possibly eliminate all of the problems which exist in a society as dynamic as ours, your present national officers and board feel that the new structure is definitely a major step forward in the history of the American Institute of Industrial Engineers.

To give each of you a feel for some of the improvements made, it might be in order to discuss some of the major areas in more detail. For instance, in the current organization, ten functions report directly to the President. Under the new structure only five officers will report to him. In the present structure, eighteen different functions report to the First Vice President. Now, only eight will report to this man who is re-identified as Executive Vice President. I think all of you will agree that this should greatly relieve two of the key officers, making it possible for them to do a better administrative job.

To bring about strong continuity in the long range development of the Institute, particularly in the area of professional development and professional relations, research, and long range development of policy, a new position, Vice President—Professional Services and Planning, has been established.

Directors for each of the foregoing functions will report directly to this new position. This new Vice President will also become a member of the Board of Trustees and the Executive Committee, which will regularly expose him on a monthly basis to the many problems received from the chapters. This should enable the long range group to get a better feel of the problems which are encountered by the backbone of our organization, our membership.

The national chairmen heading up the functions which are closely related to the month-to-month operation of the chapters will report directly to the Executive Vice President. This change and the creation of the Professional Services and Planning Group, will certainly reduce the overlap of effort which has existed for some time between many national committees.

During the past few years, many of us have encountered problems in getting clearance and approval for conferences. We have complained about delays in getting membership applications processed, and many of us have been concerned that we really do not know what is going on in the national organization.

While it is not possible to eliminate all of the irritations, we are confident that placing more activities under the control of the Executive Secretary is a step in the right direction. Another area of complaint, which has been heard so often in the past, is the lack of coordination in publications. With the newly created job of Vice President—Publications, this problem should be alleviated. This centralized function should be able to provide single source answers to our most vexing problems.

Any time a new organization is developed, new positions are established. Let's look at some of these important functions.

1. A chairman has been established for community services. There has been a great need for more development in this area, and it will help the chapters in knowing what can be done in contributing to the betterment of the community.
2. Another newly created job is the chairman of conference budgets. There has been a need for this type of guidance for some time, and we are confident that development work which can be done by this chairman will greatly enhance our financial situation.
3. For some time many of the leaders in the Industrial Engineering profession have indicated a need to establish conditions of practice and ethics for our work. The new organization provides for this and while it will take some time to develop the needs of enforcement and controls in this area, a start has been made.
4. The Professional Relations Committee has traditionally been one of our largest and most active bodies. In recognition of the outstanding contributions to the recognition and enhancement of status of our profession, this activity along with professional development is assigned to a very prominent role in the new organization.

While many details still remain to be worked out, such as the development of specific job descriptions, we are all confident that the new organization of the American Institute of Industrial Engineers will enable our society to meet the many challenges which lie ahead during the Sixties. After the new organization structure has been in operation for a few months it is possible that some minor refinements may become necessary. I am sure that all of you will be patient with the next administration until they can get all of the "bugs" worked out. I know that I am speaking for all our members when I pass along a deserving "well done" to Jack Jericho and his committee.

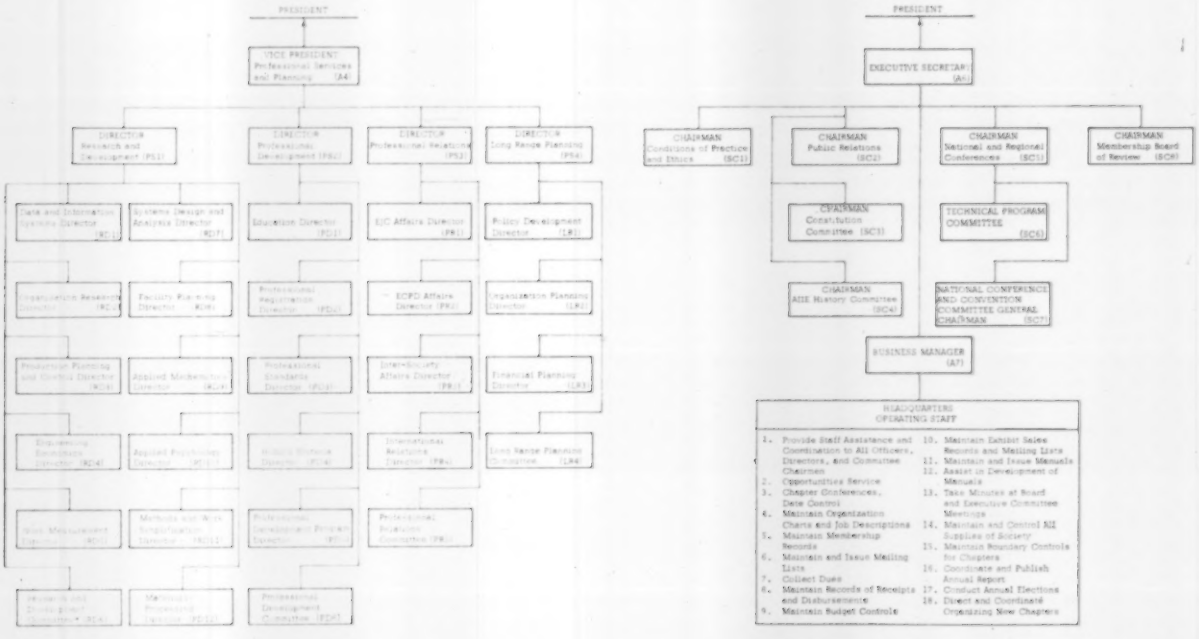
PRESIDENT
EXECUTIVE SECRETARY (A1)
CHAIRMAN Conditions of Practice and Ethics (SC1)
CHAIRMAN Public Relations (SC2)
CHAIRMAN National and Regional Conferences (SC5)
CHAIRMAN Membership Board of Review (SC8)
CHAIRMAN Constitution Committee (SC3)
TECHNICAL PROGRAM COMMITTEE (SC6)
CHAIRMAN AIIE History Committee (SC4)
NATIONAL CONFERENCE AND CONVENTION COMMITTEE GENERAL CHAIRMAN (SC7)
BUSINESS MANAGER (A7)
HEADQUARTERS OPERATING STAFF
1. Provide Staff Assistance and Coordination to All Officers, Directors, and Committee Chairmen
2. Opportunities Service
3. Chapter Conferences, Date Control
4. Maintain Organization Charts and Job Descriptions
5. Maintain Membership Records
6. Maintain and Issue Mailing Lists
7. Collect Dues
8. Maintain Records of Receipts and Disbursements
9. Maintain Budget Controls
10. Maintain Exhibit Sales Records and Mailing Lists
11. Maintain and Issue Manuals
12. Assist in Development of Manuals
13. Take Minutes of Board and Executive Committee Meetings
14. Maintain and Control All Supplies of Society
15. Maintain Boundary Controls for Chapters
16. Coordinate and Publish Annual Report
17. Conduct Annual Elections
18. Direct and Coordinate Organizing New Chapters

FIG. 2. American Institute of Industrial Engineers, Inc. National Organization Chart

Professional Relations

ANNUAL REPORT ENGINEERS JOINT COUNCIL ACTIVITIES

The AIIE is one of the 10 constituent societies that make up the Engineers Joint Council. During the past year we participated on 12 major committees of the EJC in addition to being represented on both the Board of Directors and the Executive Committee.

Constitution and By-Laws—(Mr. Irving A. Dellhoff)

This committee considers proposals for changes in the Constitution and By-Laws of the EJC and makes recommendations to the Board of Directors. In 1959 a study was completed of the term of office of members of the Engineering Manpower Commission.

***Employment Conditions*—(Mr. R. A. Engle)**

A report was prepared showing the trend of union activities over the last 3 years on engineering campuses. A copy of this study was submitted to all constituent societies for their information and use.

A study was completed but not yet issued on the subject of safeguarding confidential company information.

A current backlog exists of 30 projects for this committee to study.

***Engineering Manpower Commission*—(Mr. Clifford H. Doolittle, Mr. C. R. Boyer and Mr. J. F. Jericho)**

During the year, the commission published reports summarizing the results of two major surveys conducted during the year: Demand for Engineers, and Engineering Graduate Placement. A related special study was also made of trends in Freshman Engineering enrollment.

Work is continuing in coordination with the Scientific Manpower Commission to find a satisfactory approach to implementing the recommendations developed in the study on Government Contract Procedures and Engineering Manpower utilization.

The EMC continued to issue jointly with the Scientific Manpower Commission, *The Engineering and Scientific Manpower Newsletter*.

***Engineering Sciences*—(Dr. J. M. Juran)**

As a result of a study by this group the EJC has submitted a proposal to the National Science Foundation asking for a grant of $34,000 with which to prepare a plan for developing a complete National Engineers Register.

This committee also submitted recommendations to the President of the United States for appointments to the Board of Directors of the National Science Foundation.

An effort is also under way to secure increased funds from the National Science Foundation for engineering research.

***Honors for Engineers*—(Dr. William J. Jaffe)**

This group has under study the advisability and feasibility of a "Hall of Fame for Engineers." In addition, this committee is responsible for submitting the names of Engineers to the Hall of Fame of Great Americans that is housed at NYU.

One future project of interest is the selection of individuals for nomination for the National Medal of Science.

***International Relations*—(Professor David B. Porter, Mr. Lloyd Smiley and Mr. Samuel Stephenson)**

The chief responsibility of this committee is to cooperate with engineering groups in other countries. Its major area of activity has been with the Pan-American Federation of Engineering Societies in connection with the Sixth Convention to be held in Argentina in September, 1960. This group is also participating in a Pan-American Conference on Engineering Education in cooperation with the American Society of Engineering Education.

This group is also responsible for arranging the exchange of students between countries for training within industry.

In December, 1959, the Committee was host at a meeting with Science Attaches of Foreign Countries held in Washington.

A future project of interest is the possible formation of a Pacific Far East Federation of Engineering Societies.

***Membership Committee*—(Mr. Arthur C. Seccia)**

During the past year this group reviewed and recommended for approval the requests of the North Carolina Society of Engineers and the American Railway Engineers Association for membership in the EJC.

***Public Relations*—(Mr. O. J. Feorene)**

The most significant accomplishment of this committee was on the public service advertising program undertaken early in the year.

Space was purchased in *Editor and Publisher* that was seen by 20,000 publishers, editors, reporters, and radio and TV newsmen with the object of improving their understanding of engineers and engineering.

Reprints of these ads and other publicity releases also reached the editors of all member society publications; editors of 100 company magazines, and 348 Engineering and Science publications in this country.

***National Engineers Committee*—(Mr. John Shelton)**

The chief responsibility of this committee is to assist in the formulation of sound policies respecting national affairs wherein the engineering profession can be helpful through the services and advice of its members.

***Recognition of Specialties*—(Mr. Warren E. Alberts)**

The responsibility of this group has undergone a basic change. Its new charge is to investigate and make recommendations on the ways and means of bringing about further cooperation among member societies. This is an important change in direction and one which is of vital interest to us.

***EJC-ECPD Committee on the Practice of Engineering*—(Mr. Henry Owades)**

This group has been working on a policy on the corporate practice of engineering. There is much work yet to be done before unanimity between all the member societies can be achieved.

***Who's Who in Engineering*—(Col. Frank F. Groseclose)**

The past year has been spent in working with Deans and Alumni Secretaries in seeking out and recommending to Editors of *Who's Who in Engineering* those engineering graduates whose records for the past 10 years or more clearly show inclusion of their accomplishments would be of special value to the areas of the publication.

***Automation Committee*—(Dr. A. W. Rathe)**

This committee is charged with an examination of the broad field of automation and to report the recommendations as to

what action EJC might take in preparing a comprehensive study of this field.

During the past year, AIIE has been represented on both the EJC Board of Directors and the Executive Committee by Dr. A. W. Rathe, with Mr. H. Ashcroft, Jr., alternate.

In addition to the work carried on in connection with EJC committees four task forces were assigned with specific responsibilities during the past year:

1. *A Task Force to Determine the Requirements for AIIE Delegates to the EJC*—(Mr. Robert S. Rice—Chairman, Dr. W. J. Jaffe and Mr. Morley Mathewson)

This task force completed its study before the deadline that had been established. The recommendations were submitted to the Board of Trustees in October, 1959, by Dr. Rathe and approved at that time.

2. *The EJC Tenure Task Force*—(Mr. Herbert Ashcroft, Jr.—Chairman, Mr. Warren E. Alberts and Mr. John Yaklevich)

This task force submitted a report to Dr. Rathe recommending in brief that the term of office of the principal delegates be three years, alternates be appointed to succeed the principal delegate, the Board of Trustees approve the personnel selected for EJC Committees and further recommending that the duties and responsibilities of AIIE Delegates should be defined. This task force expects to complete its work early in the year.

3. *Task Force on EJC Procedures*—(Mr. John R. Shelton)

The main purpose of this task force is to prepare a policy statement to be used as a guide by AIIE members on EJC Committees and also to prepare the necessary administrative procedures to be followed by the delegates.

A draft of both policy statement and procedures has been completed and is in the process of review.

4. *Task Force on Selecting Personnel for EJC Committees*—O. J. Feorene—Chairman, Irving A. Delloff and Arthur C. Seccia)

All National Officers, Board Members at large, Chapter Presidents, Past National Presidents and Regional Vice Presidents and Members of the Professional Relations Committee were contacted for recommendations of individuals qualified to serve on EJC Committees. As a result of this survey a preliminary list of thirty outstanding Industrial Engineers holding down responsible positions in this country has been prepared.

Complete informational background is now being accumulated for each of these individuals and a summarized list will be submitted to the chairman of the Professional Relations Committee on or before the first of April, 1960. After approval by the Chairman and the Board of Trustees this list will be used to fill vacancies or new positions arising from relationships with the EJC.

Generally speaking, Industrial Engineering activity was characterized by active, intelligent, and well received participation that reflects our sound judgment in insisting that only outstanding members of our profession be assigned the responsibility of representing the AIIE in the Engineers Joint Council.

Respectfully submitted,
O. J. Feorene, *Director, EJC Affairs*

Recent Readables

AUTOMATION

"Engineering Application of Digital Computers," H. D. Irwin, MECHANICAL ENGINEERING, *page 49, January 1960.*

Are computers worth while, and are they being used effectively? This question discussed from the viewpoint of the practicing engineer. (*J. M. Barksdale—Ethyl Corporation*)

"What's Ahead in Automation for the Nation's Smaller Office?" Robert N. Smith, OFFICE MANAGEMENT, *page 19, October 1959.*

Computer manufacturers are pushing service center concept as one answer to small concerns' dilemma over high costs.

"LACT: 4 Years Old and Growing Fast," THE OIL AND GAS JOURNAL, *page 76, December 7, 1959.*

In many crude oil fields a new and inexpensive Lease Automatic Custody Transfer system is gaining increasingly wider acceptance. Advantages are—elimination of expensive tankage, increased value of the oil, increased safety and drastic reductions in paper and record work. Fully automated oil and gas production within 5 years using digital-computer control is now being predicted. (*A. L. Friedrichs—Ethyl Corporation*)

GENERAL

"You Told Them You're Unhappy," R. F. Fremed, CHEMICAL ENGINEERING, *December 14, 1959.*

Conflict between the engineering mind and the management mind is still a fundamental and unresolved problem in American industry, according to a study just released by Opinion Research Corporation (ORC), Princeton, N.J. ORC reports that engineers and scientists working for large corporations are anything but happy with their lot. This frank and objective article lists basic conflicts between managers and engineers, gives reasons behind the conflicts and discusses new approaches to resolving the conflicts. (*J. M. Barksdale—Ethyl Corporation*)

"Here's Easy-Way Job Scheduling," H. R. Reep, FACTORY, *page 67, December, 1959.*

A template and a tabular report banish scheduling problems for General Electric in many plants where several thousand product variations are assembled from stock and non-stock subassemblies, for which specifications and raw materials are already available. A print-out report totals cycle time for each component, shows various manufacturing areas and capacity, several weeks ahead. The right template, placed over the print-out report, reveals loading, week by week, for sequential manufacturing areas. (*B. M. Bryant—Ethyl Corporation*)

"Chart Your Way to Better Maintenance," FACTORY, *page 148, December, 1959.*

Looking for better maintenance productivity? One way to get it, maintenance experts say, is by better supervision. Give your supervisors the right facts to make intelligent decisions. Management people at Aluminum Company of Canada have found that four simple trend charts telegraph the facts:

1. Crew Work Backlog
2. Percent of Work Planned
3. Job Estimate Accuracy
4. Performance Index

(*B. M. Bryant—Ethyl Corporation*)

"Developing Managerial Abilities," F. F. Bradshaw, MECHANICAL ENGINEERING, *page 29, January 1960.*

There is widespread experimental literature to prove that about three fourths of the best managers share certain common characteristics. These characteristics, when spelled out, digested, and interpreted, point to an individual who is emotionally mature and relaxed, not likely to take it out on others, apt to have time for planning and personnel problems. (*J. M. Barksdale—Ethyl Corporation*)

"Obligations of an Engineer," Glenn B. Warren, MECHANICAL ENGINEERING, *page 51, January 1960.*

If we can't see beyond our profession, the profession suffers. Here are excerpts from President Warren's address at the Society's Semi-Annual Meeting, a directive to engineers to broaden both their thinking and active participation in public affairs. (*J. M. Barksdale—Ethyl Corporation*)

"Four Ways to Spur Production On Your Present Plant Site," J. R. Walley, IRON AGE, *page 109, December 3, 1959.*

A proven four-way system should help every company meet the heavy demands of the coming boom without adding floor space to your present plant.

"An Analysis of Scientific Management Wage Theories," James H. Greene, ADVANCED MANAGEMENT, *page 16, November 1959.*

The absence of definite statements on wage theory in the writings of F. W. Taylor has led the author to search the history of wage theories for one or more to which Taylor would subscribe. In this article, the classic wage theories are first discussed briefly —then each is scrutinized in the light of the available writings of the "Father of Scientific Management."

"The Board of Directors: Its Composition and Significance," Robert E. Kennedy, Jr. and Rhea H. West, Jr., ADVANCED MANAGEMENT, *page 8, November 1959.*

With the general separation of management and ownership, corporate objectives are frequently blocked by conflicting interests among public opinion, consumers, employees, stockholders and government. Successful reconciliation may depend on the Board of Directors.

"Using Retired Executives as Teachers of Business Policy," Thomas N. St. Hill and Waino W. Suojanen, ADVANCED MANAGEMENT, *page 4, November 1959.*

Not only do students benefit from a close relationship with a "real" executive . . . he is also one of the factors to be considered by the university administrator faced with a shortage of professional instructors.

"Our Present Industrial Troubles—And The Office," Robert M. Smith, OFFICE MANAGEMENT, *page 21, November 1959.*

Labor's current last-ditch fight against changes in work rules may foreshadow new interest in office unionization.

"How Real Is The Engineer Shortage," Earl C. Hubicek, INDUSTRIAL RESEARCH, *Summer 1959.*

There has not been one year in this decade when the requirements were satisfied by hirings. This shortage has driven starting salaries up 83% in the past ten years—this year's average is estimated at $475. Salaries of experienced engineers have not kept pace. This combination of factors is fostering job changing of experienced engineers at an unprecedented scale. Another detrimental factor is the use of engineers as non-professional technicians. There is no strong desire to stay in the technical field, and the managerial route is looked upon as the only route to advancement. (*A. L. Friedrichs—Ethyl Corporation*)

MATERIALS HANDLING

"The Economics of Containerization," C. W. Bent and Vaughan Spalding, MATERIAL HANDLING ENGINEERING, *page 80, November 1959.*

Transportation authorities have little doubt that containerization, the principle of using a physical "envelope" to consolidate a large number of individual packages or units for shipment, is the next major development in transportation. Containerization is a concept combining transportation with packaging, material handling, and distribution and can bring lower handling costs and speedier shipments for many companies, both large and small. (*N. E. Sparks—Ethyl Corporation*)

"How to Select Your Drive System," W. B. Wilson and I. H. Landes, OIL AND GAS JOURNAL, *page 113, December 7, 1959.*

In 1955 and 1956, the chemical and petroleum industries spent over 2 billion dollars for their purchased fuel and electric-power requirements. This cost for energy is 15% greater than the total expenditure for new machinery and equipment during this same period. Thus the importance of proper drive equipment is brought home.

"A Look at Future Needs," Lt. Colonel G. A. Davies, U.S.A.F., MATERIAL HANDLING ENGINEERING, *page 56, December 1959.*

The author outlines the tremendous material handling problems to be faced by the Air Force in the Space Age. To meet the accelerating demands, he mentions such possibilities as spray-packaging of parts on a fast conveyor line, photographic labeling of packages on a conveyor line giant pneumatic conveyor system, and rocket transportation of cargo. (*N. E. Sparks—Ethyl Corporation*)

QUALITY CONTROL

"How Value Analysis Promotes Better Product Acceptance," R. H. Eshelman, IRON AGE, *page 117, November 19, 1959.*

Why over-design? All the end user wants is performance.

Give your own work-force the job of frill-cutting. But it takes a real system to put it into practice.

"Product Quality: Pretty Good Isn't Good Enough," Frank H. Squires, THE MANAGEMENT REVIEW, *page 18, October 1959.*

Quality control should control all activities that affect the quality of the product, including the sources from which raw materials and components are purchased and the fabricating process within the plant. This function with such widespread influence should not be subordinated to any single department. It is essential that top management be involved since it alone can give sufficient authority to the board controls that are necessary. (*A. L. Friedrichs—Ethyl Corporation*)

"How to Lose At The Quality Control Game," Brainard E. Sooy, QUALITY CONTROL, *page 14, October 1959.*

A lack of knowledge, a certain amount of bull-headness and disregard for the laws that govern men's actions and reactions can cause failure in a Quality Control program. Starting with too large an organization, using complicated control charts and unintelligible reports, and making himself and his inspectors unacceptable to the workers and supervisors, will assure the failure of a Q. C. engineer. (*A. L. Friedrichs—Ethyl Corporation*)

SYSTEM AND PROCEDURES

"The Office Prepares for Tomorrow's Challenge," The Editors, DUN'S REVIEW AND MODERN INDUSTRY, *September 1959.*

In most companies, the cost of office operations is rising year by year. Despite some successes in individual concerns, management as a whole is still a long way from getting the paperwork under control. This eight-part Special Report to Management examines the basic changes that are now taking place in office operations all across the nation, as management prepares for a decade of expansion. *(J. M. Barksdale—Ethyl Corporation)*

"How We Cut Plant Paperwork 87 Percent," Lester E. Bond, OFFICE MANAGEMENT, *page 39, October 1959.*

Production is speeded, too, by defense contractor under new simplified system for processing purchasing orders at Vinson Mfg. Co.

"Every Order Filled in a Day," Stanley J. Dziuban, OFFICE MANAGEMENT, *page 27, October 1959.*

The proud accomplishment of Anaconda Wire and Copper since its installation of a new communications system to speed order processing.

WORK MEASUREMENT

"Work Sampling in Maintenance," FACTORY, *page 72, December 1959.*

How United Air Lines has succeeded in lifting from 54% to 77% the productive use of a worker's time at its San Francisco maintenance center. *(B. M. Bryant—Ethyl Corporation)*

"Checking Machine Use—Scientifically," Donald W. DeVoss, OFFICE MANAGEMENT, *page 30, November 1959.*

Direct observations of machine usage—at random intervals and in alternating sequence—can furnish a reliable guide to need. Another application of the work sampling technique.

BOOKS

"Proceedings of Engineering Economy Symposium," jointly sponsored by AIIE and ASEE, Pittsburgh, June, 1959, THE ENGINEERING ECONOMIST, *Stevens Institute of Technology, Hoboken, New Jersey, $4.00 (schools, public libraries and educators), $10.00 (others).*

THE EDUCATION OF AMERICAN BUSINESS MEN, *by Frank C. Pierson and others, McGraw-Hill Book Company, Inc., New York, 1959, 740 pages, $7.50.*

ENGINEERING ECONOMY *(Third Edition), by E. Paul De Garmo, The Macmillan Company, New York, 1960, 580 pages.*

IDEAS FOR MANAGEMENT, *papers and case histories presented at the Eleventh Annual International Systems Meeting, Colver Gordon, Editor, The Systems and Procedures Association, Publisher, 4463 Penobscot Building, Detroit, Michigan, 1959, 440 pages.*

BUSINESS EXPERIENCE WITH ELECTRIC COMPUTERS, *by B. Conway, J. Gibbons, D. E. Watts, Directors of Price Waterhouse and Company, New York, a report prepared for Controllers Institute, Research Foundation, Inc., 2 Park Avenue, New York 16, New York, 1959, 191 pages.*

OPERATIONS RESEARCH, *an Annotated Bibliography, by James H. Batchelor, St. Louis University Press, St. Louis, Missouri, 1959, 865 pages, $10.00.*

THE ANALYSIS OF VARIANCE, *by Henry Scheffe, John Wiley and Sons, Inc., New York, 1959, 477 pages, $14.00.*

REGRESSION ANALYSIS, *by E. J. Williams, John Wiley and Sons, Inc., New York, 1959, 214 pages, $7.50.*

METHODS OF CORRELATION AND REGRESSION ANALYSIS, *Linear and Curvilinear, (Third Edition), Mordecai Ezekiel and Karl A. Fox, John Wiley and Sons, Inc., New York, November 1959, 548 pages, $10.95.*

INDUSTRIAL COMPLEX ANALYSIS AND REGIONAL DEVELOPMENT, *by Isard, Schooler and Vietorisz, Technology Press of MIT and John Wiley and Sons, Inc., New York, 1959, 294 pages, $8.75.*

COMPETITIVE INTELLIGENCE—*Information, Espionage and Decision-Making, by students at the Graduate School of Business Administration, Harvard University, Burton H. Alden, Byron C. Campbell, Thomas W. Courtney, Anilkumar M. Chandaria, Albert A. Ewald, John A. Griner and James B. Moffat, published by C. I. Associates, Watertown, Massachusetts, 1959, 78 pages, $10.00.*

INDUSTRIAL ORGANIZATION, *by Joe S. Bain, John Wiley and Sons, Inc., New York, 1959, 643 pages, $9.25.*

THE MOTIVATION TO WORK, *by Herzberg, Mausner and Snyderman, John Wiley and Sons, Inc., New York, 1959, 157 pages, $4.50.*

PROPERTIES OF MATTER, *by F. C. Champion and N. Davy, Philosophical Library, Inc., New York, 1959, 334 pages, $10.00.*

MODERN ELECTRONIC COMPONENTS, *by G. W. A. Dummer, Philosophical Library, Inc., New York, 1959, 472 pages, $15.00.*

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CALENDAR

April 21-28: American Society of Tool Engineers 1960 Tool Show and Annual Convention, Artillery Armory, 15000 W. 8 Mile Road, Detroit, Michigan. (Technical Sessions—Sheraton-Cadillac Hotel, Detroit, Michigan.) Write: Harry E. Conrad, Executive Secretary ASTE, 10700 Puritan Avenue, Detroit 38, Michigan.

June 6-10: Machinability Seminar emphasizing the new difficult-to-machine materials will be held on the campus of The Pennsylvania State University from June 6-10, 1960. For additional information, write: Machinability Seminar, Conference Center, The Pennsylvania State University, University Park, Pennsylvania.

June 6-16: Short Course on Operations Research Methods will be held at Purdue University. The course has been designed specifically for statisticians, quality control analysts, engineers, and other technical personnel in industrial and management positions. Write: Short Course on Operations Research Methods, Comptroller's Office—University Extension Administration, Memorial Center, Room 110, Purdue University, Lafayette, Indiana.

June 6-17: Intensive Course in Operations Research and Systems Engineering for business, industrial and government personnel. This course will be held at the Homewood Campus of the Johns Hopkins University in Baltimore. For further information, write: Dean, School of Engineering, The Johns Hopkins University, Baltimore 18, Maryland.

June 12-25: Seventh Annual Training Course in Materials Handling and Packaging, Lake Placid Club, Lake Placid, New York. Write: James R. Bright, Director, The Industrial Management Center, 56-J Robbins Road, Lexington, Massachusetts.

June 13-22: A nine-day course entitled "Industrial Statistics and Quality Control for the Chemical and Processing Industries" will be held at Rochester Institute of Technology, Rochester, New York. Write: Harold M. Kentner, Assistant Director of Extended Services, Rochester Institute of Technology, Rochester 8, New York.

June 14-17: Industrial Engineering Seminars, Cornell University, Ithaca, New York, for managers and professional staff. Participants enroll in one of the following groups and also attend general sessions: A. Industrial Management, B. Engineering Administration, C. Operations Management of the Smaller Company, D. Work Measurement, E. Systems Simulation Using Digital Computers, F. Statistical Decision-Making: Theory and Applications, G. Statistical Reliability Analysis: Theory and Applications. Leaders will be from industry and the staff of Cornell University. For additional information write: J. W. Gavett, Seminars Coordinator, Department of Industrial and Engineering Administration, Upson Hall, Cornell University, Ithaca, New York.

June 19-22: The Seventh National Conference on Campus Safety sponsored by the National Safety Council will be held at Cornell University. Campus safety officials from throughout the United States will view demonstrations by a large number of exhibitors of new equipment and approaches to solving college safety problems. Registration and housing information may be obtained from Francis J. Quinlan, Assistant Supervisor, Safety Division, 101 Day Hall, Cornell University, Ithaca, New York.

June 20-24: "Recent Industrial Engineering Developments," College of Engineering, The University of Michigan, Ann Arbor, Michigan. Write: R. E. Carroll, Coordinator, Engineering Summer Conferences, College of Engineering, The University of Michigan, Ann Arbor, Michigan.

June 23-30: A course entitled "Design of Experiments in the Chemical and Processing Industries" will be held at Rochester Institute of Technology, Rochester, New York. Write: Harold M. Kentner, Assistant Director of Extended Services, Rochester Institute of Technology, Rochester 8, New York.

Sept. 30-Oct. 1: 1960 Western Regional Conference AIIE, Salt Lake City, Utah. Write: Mr. H. D. McTague, Chairman, 1960 Western Regional Conference, P. O. Box 510, Provo, Utah.

November 14-18: ASTE 1960 Western Tool Show and 28th Semiannual Meeting, Sports Arena, Los Angeles, California. (Technical sessions—Ambassador Hotel, Los Angeles, California.) Write: Harry E. Conrad, Executive Secretary ASTE, 10700 Puritan Avenue, Detroit 38, Michigan.

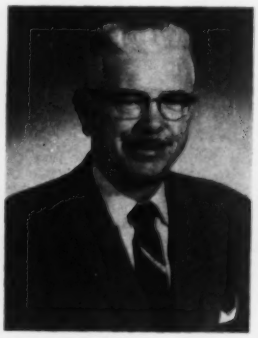
PERSONALITIES

CHARLES A. BOGENRIEF

The president of Robertshaw-Fulton Controls Company of Richmond, Virginia, announced in December that Charles A. Bogenrief had been elected Vice President, Manufacturing. Mr. Bogenrief has been Director, Facilities and Tooling. He is a registered professional engineer in mechanical engineering, past president of the Los Angeles chapter of the Society for the Advancement of Management, and past national director of the Methods-Time-Measurement Association for Standards and Research. Mr. Bogenrief is past president of the Los Angeles chapter of the American Institute of Industrial Engineers. He has written several articles for trade magazines, and has presented papers before technical and professional groups.

BEN S. GRAHAM

Ben S. Graham, late director of the systems and procedures division of The Standard Register Company, Dayton, Ohio, died on January 7, 1960, at the age of 59.



Ben Graham had been long acknowledged as a pioneer and an international authority on the subject of paperwork simplification, systems analysis and other related management techniques. A native of New York City, he joined Standard Register in 1942 as a systems analyst. In 1944 he was transferred to the head office in Dayton where he served in various capacities—as director of the formcraft division and director of methods research. He was appointed director of the systems and procedures division in 1957.

For more than 20 years Ben Graham pioneered in the field with which he became identified—the outgrowth of work simplification known as paperwork simplification. During that time he formed

close friendships with Allen Mogensen and Dr. Lillian Gilbreth, the two foremost proponents of work simplification.

Throughout his career Mr. Graham did a great deal to stimulate interest in his field through his discussions and presentations before business groups in the United States and Canada and through his lectures and special industrial training programs at such institutions as M.I.T., UCLA, New York University, Northwestern University, the University of Iowa, the University of Wisconsin and many others. He was a staff member of the Mogensen Work Simplification Conference in Lake Placid, New York, and of the University Work Simplification Round Table, Wharton School, University of Pennsylvania.

Mr. Graham was the author of countless articles on work simplification and a prominent speaker before local and national chapters of NOMA, NAA and similar professional groups. He was a member and served in a national capacity for the Society for the Advancement of Management and the American Institute of Industrial Engineers. He was also a member of the American Management Association, the Industrial Management Society, NOMA, NAA and the Society for Quality Control.

E. PAUL LANGE

On March 7 Mr. E. Paul Lange, since 1954 Executive Secretary of the Engineers Joint Council, assumed office as Executive Secretary of the American Institute of Industrial Engineers, succeeding Floyd Titler who retired on April 1.

Mr. Lange is a man who is universally known and respected in all branches of the engineering profession—in this country and many nations abroad; the initials EPL stand for top integrity and ethics as much as they signify a proven record of effective society administration. This is a matter of very real significance to all AIIE members, *Journal* readers, and the engineering fraternity as a whole.

Paul's principal hobby is stream fishing. He likes nothing better than to cast a lure in an inviting trout pool. In his professional capacity he continues to work at his hobby—except that in the latter case his enthusiasm and competence provide the stimulus to motivate more and more members of our enormous pool of engineering manpower into active and fruitful participation in society activities. When accepting the post of Executive Secretary of EJC in 1954 the Council consisted of eight engineering societies with a membership of approximately 170,000. Upon relinquishing his post on March 7, 1960, the Council had increased to thirteen national societies and eight affiliated or local groups with a membership upward of 300,000 all of this in six years.

AIIE is extremely fortunate in having as its Executive Secretary a dynamic leader such as Paul Lange, whose skills in the fields of planning, organization, and administration are of the highest order.

Paul Lange was born in Seattle, Washington, and received his Bachelor of Science degree in Mining Engineering from the University of Washington. With the exception of a brief interlude in the Armed Services, he was actively engaged in mining and engineering activities from 1940 to 1954. His assignments took him to Alaska, Montana, and several locations in Saudi Arabia and South America. In addition to the technical engineering aspects of these assignments, he also worked in the areas of operational designs and layouts. For a period of two years, he served in the United States Army Counter Intelligence Corps with headquarters at Bamberg, Germany. He was released to inactive duty as a First Lieutenant, United States Army Reserve.

In the course of his work as Executive Secretary of EJC, Paul instituted many innovations in the administration of the Council's activities. He is a great believer in stimulating new memberships to a society at the personal man-to-man level and, more important, keeping these memberships active.

As a help towards the motivation of active membership, he is fully aware of the Institute's responsibility to bring the conferences to the members—not the members to the conferences. Many of our major industries in this country are concentrated in reasonably small geographical areas such as aircraft industries on the west coast, textiles in the southeastern area, etc. He has found that if the agendas of the regional and local society meetings are related to the industry or industries which are predominantly present in the respective geographical areas, the participation and attendance at these meetings will be greatly increased. The fact that a society is, in this manner, taking active interest in the problems of the geographical areas acts as a direct stimulant to the generation of new and actively participating memberships. He believes that national meetings serve a very useful purpose and are very beneficial to AIIE in advising the membership of the overall progress it is making as a society within the EJC and the entire engineering fraternity. He emphasizes, however, that the real work must be done at the grass-roots, the regional and local levels.

AIIE can be sure that Paul Lange will give unstintingly of his enthusiasm and dynamic leadership as our Executive Secretary. He looks upon Industrial Engineers as the younger, up-and-coming group of engineers who can render invaluable service to this country by closing the gap between technical engineering and management. Industrial Engineers, in addition to possessing competent technical background, must also be skilled in human engineering and economics. Only by so doing will they truly achieve their rightful place in the management complex.

Paul is a member of the American Institute of Mining, Metallurgical and Petroleum Engineers; the American Institute of Industrial Engineers; the American Society of Mechanical Engineers; and a Fellow in the American Association for the Advancement of Science. He is forty-three years old and, with his wife and two children Marjorie 5½ and John 4, lives in Great Neck, Long Island, New York.

PAUL N. LEHOCZKY

Dr. Paul N. Lehoczky was one of the three members appointed by President Eisenhower to a fact-finding board to inquire into the steel strike of 1959. The other members are Chairman George W. Taylor of the University of Pennsylvania and Dr. John A. Perkins, president of the University of Delaware.

The board reported to the President October 19 what the issues in dispute and the position of the parties were, and the government proceeded under the injunctive provisions of the Taft-Hartley Act in a move to re-open the mills.

Dr. Lehoczky's arbitration practice has been chiefly in the basic steel industry, steel products, glass, chemical, rubber, aircraft and metal-working industries. He is permanent arbitrator for a number of contracts including Pittsburgh Plate Glass, Westinghouse Electric and Manufacturing (on work standards); Firestone Tire and Rubber (panel member); Goodyear Tire and Rubber (southern textile mills); Seagrave Corporation (panel), and others, and in the past has served in similar capacity for Goodyear Aircraft; Libby Owens Ford, and others. He is chairman of a three-man board empowered to write certain sections of the labor contract which could not be resolved after a 142-day strike between the Pittsburgh Plate Glass Company and the United Glass and Ceramic Workers.

His interest is primarily in engineering disputes involving job evaluation, wage evaluation and incentives, but he has handled all other kinds of disputes.

Dr. Lehoczky has been engaged in the consulting field since 1930, also primarily in basic industries. He was a panel chairman, technical expert and arbitrator with the National War Labor

Board and National Wage Stabilization Board from 1943 to 1946, Commissioner of Conciliation (technical) for the Federal Mediation and Conciliation Service 1946-47, and adviser to the Ohio Industrial Commission 1941-56. He was Ohio representative to the National Pressure Vessel Inspectors' Board, 1940-44; Ohio representative of the ASME Boiler Code Committee, 1940-44; for five years member of the Ohio Apprenticeship Council; member of the National Academy of Arbitrators, American Institute of Industrial Engineers, Life Member of the American Society of Mechanical Engineers, and others. He is past chairman of the Industrial Engineering Division of the American Society for Engineering Education and member of the Society's Council, 1946-47.

A registered Mechanical and Industrial Engineer (Ohio), Dr. Lehoczky is a graduate of Case Institute of Technology, 1927, and holds master's and Ph.D. degrees from Ohio State.

In addition to attaining a distinguished career in education, he has become one of the nation's leading arbitrators of technical labor-management disputes and in this capacity has arbitrated over 2400 labor-management dispute issues.

Dr. Lehoczky has been with the Department of Industrial Engineering at The Ohio State University since 1928 and Chairman of the Department since 1944.

SAMUEL S. STEPHENSON, JR.

Mr. Samuel S. Stephenson, Jr., Vice President-Intersociety Relations has been elected to the Board of Directors of The Technical Societies Council of New York. This organization consists of representatives of the major engineering societies in the New York area. Mr. Stephenson's election to this important office demonstrates the growing recognition of Industrial Engineering and the American Institute of Industrial Engineers, as well as Mr. Stephenson's many accomplishments in the engineering profession.

RALPH W. UPDEGRAFF

Henry A. Tobey, Vice President in Charge of Manufacturing, Bearing and Rock Bit Divisions of the Timken Roller Bearing Company, announced the appointment of Ralph W. Updegraff to the post of General Factory Manager, Bearing and Rock Bit Divisions of the Timken Roller Bearing Company, effective December 3, 1959. Updegraff, who started with the Timken Company in 1948 as an Industrial Engineer, progressed successively to Senior Industrial Engineer, Chief Industrial Engineer of the Canton Bearing Factory, Chief Industrial Engineer of The Timken Roller Bearing Company, and in 1957 was named General Superintendent of the Canton and Gambrinus Bearing Factories, the position he held until his recent appointment. A registered Professional Engineer, Updegraff graduated from Ohio Wesleyan University. He attended Columbia University and, under the sponsorship of the Timken Company, the Institute for Management at Northwestern University. He is an active member of AIIE and has served as Treasurer since 1957.

FINANCIAL STATEMENT OF THE DWIGHT D. GARDNER SCHOLARSHIP FUND

As required by the Constitution of the Dwight D. Gardner Scholarship Fund, an audit was made for the thirteen-month period of December 1, 1958, through December 31, 1959, by W. E. Truitt, Assistant Treasurer and Comptroller, Commercial Motor Freight, Inc. and is published as follows:

Balance as of December 1, 1958		$3,168.67
Deposits	$1,251.49	
Interest Earned	183.29	1,434.78
Total		$4,603.45
Disbursements		250.00
Balance as of December 31, 1959		$4,353.45

The cash balance of $4,353.45 is the amount held in the Central Savings and Loan Company, 46 East Gay Street, Columbus, Ohio.

INDUSTRIAL ENGINEERING APPLIED TO WATERFRONT WORK METHODS

Modernized longshore work methods will be tested this month by scientists and Industrial Engineers of the Maritime Cargo Transportation Conference, a part of the National Academy of Sciences-National Research Council. The tests, to be undertaken with the cooperation of the Navy at its Oakland Supply Center, are an attempt to find what can be done to improve production and reduce waterfront cargo handling costs.

The Oakland experiments are part of a project begun in the San Francisco Bay Area two years ago by MCTC. The project is a scientific study of the turnaround time of general cargo ships. Both labor and management are interested in the project.

According to Dr. P. B. Buck, director of the local office of MCTC, "The experiments to be done at the Navy Supply Center represent a partial fulfillment of our research objectives in the Bay Area. In our two years here we have studied the work methods prevalent on the commercial waterfront in great detail. On the basis of these studies, we have designed a number of new systems which we believe are capable of doubling present-day cargo handling production. What we plan to do at Oakland is to test these systems on-the-job to find whether they will yield the production and cost reduction returns which are theoretically possible."

The new work methods incorporate some of the latest types of powered handling equipment. They include an almost complete reorganization of present work patterns and job assignment of longshore occupations according to principles of Industrial Engineering. Besides reducing cargo handling costs, increasing production and reducing the arduousness of the work, economic gains through reduced ship time in port are expected.

"The research work," Dr. Buck continued, "is designed to help solve some of the handling and cost problems of the commercial shipping industry. The Navy Center was chosen as the initial test site because of its wide range of cargo operations. It gives us a chance to test our new systems under scientific controls." The Navy will consider adopting as standard those systems that actually show major improvement in speed and cost of Navy cargo handling operations.

The researchers also plan to measure energy expenditure levels of the workmen to be certain that any production gains noted stem from the new systems rather than from increased physical exertions of a labor force. Physiologists from the Engineering Department of UCLA will undertake this portion of the research.

BOSTON CHAPTER

The first meeting of the 1959-1960 program year was held on October 19. Mr. Norman Jennings, Management Engineer in the Operations Standards Division of the Port of New York Authority, addressed the group on "Industrial Applications of Waiting Line Theory." Visual aids were used extensively to illustrate practical applications of waiting line theory in the Port Authority. The subject was well presented and stimulated the interest of those in attendance.

We were honored to have as guest speaker at our November

meeting, Mr. Frank Johnson, National President, American Institute of Industrial Engineers. Prior to the evening dinner, Mr. Johnson visited the Lighting Division of Sylvania Electric Products Inc., and CBS Electronics both located in Danvers, Mass. He was accompanied on the tours by Mr. George Martin, Chapter President and Mr. Bill Vallette, Director of Industrial Engineering at CBS Electronics and Vice President of Region I. Following the plant visitations he was taken on a sightseeing tour of historic sites located in Marblehead, Danvers, Swampscott and Salem.

A large group was in attendance at the evening meeting to hear Mr. Johnson speak on "Producibility Analysis—A Challenge to Industrial Engineers." Actual examples pertaining to problems at Lockheed Aircraft were presented and the outstanding results demonstrated the effectiveness of a well integrated Industrial Engineering activity analyzing the effects of engineering design on costs prior to actual production runs.

At the Chapter Presidents' meeting in Philadelphia on Nov. 7, Mr. George Martin submitted a bid for Boston Chapter to host for the Region I Conference and Convention for 1960; the bid was accepted. The functioning committees for establishing the conference program have been appointed and the conference dates have been set for November 3 and 4, with a Chapter Officers' meeting scheduled for November 5. The program will be held at the Sheraton Plaza Hotel, Copley Square, Boston, Mass.

DALLAS-FORT WORTH CHAPTER

The following article, Developing Professionalism in the Industrial Engineer, was prepared by the Student Affairs Committee: John F. Hamje, Manager, Industrial Engineering, Germanium Industrial Division, Texas Instruments, Chairman; Gerald H. Lumsden, Manager, Staff Industrial Engineering, Texas Instruments; and Frank W. Tippitt, Assistant Professor of Industrial Engineering, Southern Methodist University.—Ed.

REGIONAL STUDENT CONFERENCE

The future of our profession may well lie in the hands of our undergraduate students. As our industrial culture becomes more complex, its very survival is dependent upon the development of new management philosophies like those pioneered by present day Industrial Engineers. It is toward this goal that our professional activities must be directed. The colleges and universities are turning out good Industrial Engineers. The faculties of these colleges and universities, through personal contacts, in both classroom and student chapter activities, are charged with the responsibility of graduating a well educated, professional Industrial Engineer. However competent the faculties may be, they cannot do it alone. The faculties can teach the tools and techniques. They can also point the way toward professionalism. But. . . .

Hard work by faculty and student is not enough. New philosophies must be developed to cope with the growing intricacies of modern industry. What contribution is the professional Industrial Engineer called on to make to this end?

Long recognized as a valuable means of promoting the professional development are meetings, conferences, and paper presentations among professional people. Most other professional engineering groups have student groups affiliated and sponsored. They don't stop there. Individual student chapters and individual senior chapters meet together, students are invited to conferences of senior chapters, and senior chapters sponsor paper presentations contests for students, many with substantial prize money. In addition most engineering groups have a program of regional and national meetings and competitions for students.

It is now time that the AIIE also provided such meetings and paper competitions.

The Dallas-Fort Worth Chapter of AIIE is sponsoring a Regional Student Conference for the six student chapters of Region IX on May 6-7, 1960. In so far as can be determined, this will be the first regional meeting of student chapters, AIIE. This first one promises to be an outstanding success; and for a very good reason—the pressure for the conference is from the students of the Southern Methodist University Student Chapter. They conceived the idea and asked the Dallas-Fort Worth Chapter to back them up. The Dallas-Fort Worth Chapter reports that their membership enthusiastically and unanimously voted to sponsor the Conference and provided a substantial budget. Professor Charles Brennan, our National Director of Student Chapters, has given his support. Through the efforts of Professor Brennan, the National Executive Committee has appropriated additional prize money.

The objectives of the Regional Student Conference are:

1. To advance the Industrial Engineering profession by stimulating additional research and creative thinking.
2. To provide an interchange of information and ideas among student chapters.
3. To furnish an opportunity for addresses by outstanding leaders in the Industrial Engineering profession.
4. To present an opportunity for national recognition of students and student chapters.
5. To give an incentive for the preparation and an opportunity for presentation of student papers of high quality.
6. To furnish an opportunity for faculty advisors to meet.
7. To provide a guide and an incentive for future Regional and National Student Conferences.

The Student Affairs Committee of the Dallas-Fort Worth Chapter has drafted a manual of policy and procedure for the student conference. This manual provides guidance and places primary responsibility for the student conference on the host student chapter. Further, it establishes standards for the paper contest and provides a transportation allowance for visting student chapters.

This is a new step in the professional development of the student Industrial Engineer. It will set precedents. A national program may result from this regional student conference.

Eventually, there can be a national competition of regional winners. The precedent for this is also being set. The regional student conference grand prize winner will present his paper at the 1960 National Conference and receive his award at the banquet. Subsequently, individuals or industries can be encouraged to come forward with endowed annual awards.

Quoting slightly out of context, but to the point nonetheless, Dr. Gerald Nadler said, ". . . By exchanging information with others, new concepts and a more useful knowledge bank can be established. The personal contacts are essential to the professional development of the Industrial Engineer . . . (1)." Although he was writing to and about practising Industrial Engineers, the point made is equally applicable to the future Industrial Engineers who will some day provide continued professional maturity. Regional conferences of student chapters of AIIE can materially contribute to this professional development.

What action should you, the members of AIIE, be taking to insure continuing professional growth in our Institute? This is the challenge.

REFERENCE

(1) Nadler, Gerald, "Professionalism and AIIE—and You," *The Journal of Industrial Engineering*, July-August 1957, Vol. VIII, No. 4, Page 242.

HOUSTON CHAPTER

The Fifth Annual Industrial Engineering Conference on "Work Simplification" was held on November 6, 1959, at the Shamrock

Hotel in Houston. The conference was conducted by Allan H. Mogensen, founder and director of the world famous work simplification conference and assisted by Dr. Lillian M. Gilbreth internationally famous engineering and management consultant. This clinic is held annually and is presented jointly by the Houston Chapter of the AIIE and the Industrial Engineering of the University of Houston. The Clinic was a great success and well received by everyone attending. An excellent job was done by conference co-chairman Herbert R. Belcher of Ernst and Ernst and Bruce C. Stoughton of the University of Houston.

The Houston Chapter is well along on its 1959-60 program with an excellent variety of subjects chosen by the Program Committee under the able direction of Mr. E. C. Hailey. The programs during November consisted of a plant tour of facilities of Champion Paper and Fiber Company, Pasadena, Texas, one of the largest paper manufacturing plants in the country.

Three Chapter members were given distinguished service awards in appreciation of their outstanding accomplishments, inspiration and devoted efforts to further the profession of Industrial Engineering. The three members, all well known Industrial Engineers in the Gulf Coast area were: Sam Scharff of Ernst and Ernst, Tom Elrod, Chairman Department of Industrial Engineering, University of Houston (former Regional Vice President AIIE), and Fred Macy, Chief Industrial Engineer, Shell Oil Company, Pasadena, Texas. These men have been instrumental in the organization of the Houston Chapter as well as having a hand in its excellent growth.

The Houston Chapter has contributed 107 per cent of its goal to the United Engineering Building Fund, Chairman R. E. Doherty has done an excellent job in obtaining this quota.

LOUISVILLE CHAPTER

At our November meeting Mr. Donald G. Malcolm, who is with System Development Corp. in Santa Monica, California, was guest speaker. Mr. Malcolm is the National Chairman of Long Range Planning for AIIE, and a past National President of our organization. His very interesting subject for discussion was "Work Sampling as a Management Control."

Mr. J. F. Jericho, National First Vice President of AIIE and Superintendent of Methods and Standards for United Air Lines in Chicago, was featured speaker at our December meeting. The subject of his talk was "New Concepts—Industrial Engineering."

MILWAUKEE CHAPTER

The Milwaukee Chapter of AIIE was host at the Midwest Region's Productivity Conference held on Friday, November 13, at Marquette University. Fifty Industrial Engineers enrolled for this one-day meeting.

Prof. Gayle McElrath, Chairman of the IE Department at the University of Minnesota, opened the Conference with a talk on "More Effective Decision Making." Later, Boyd Payne, Director of Career Development at Kimberly-Clark Corp., spoke on "Preparing the IE for Managerial Positions."

In the afternoon, Harmon S. Bayer, Quality Control Consultant, discussed "Quality Control Techniques for the IE." This was followed by Dr. Russell L. Moberly, Personnel Consultant, who spoke about the "Role of the IE in Effecting Sound Wage and Salary Administration." He pointed out the direct connection between a sound wage and salary system and productivity. Another speaker was Clifford G. Sager, of Sager Film Productions, who outlined "Effective Use of Motion Pictures for Training and For Selling Ideas," emphasizing the communication power of visual aids.

The dinner speaker was Dr. Robert N. Lehrer, Chairman and Professor of Industrial Engineering, Technological Institute, Northwestern University. Lehrer spoke about "New Insights into Productivity Concepts." He emphasized that with the new problem approaches developed in recent years, Industrial Engineering is now entering an era where its true function—that of advising top management in problems of system-wide nature—can now be realized. Industrial Engineers must meet this challenge by preventing practices from becoming static, and by continuing to become more adept in the use of newer, more powerful methods.

In conjunction with the Production Conference, Midwest Region Vice President Arthur Aronson held a Chapter Presidents' Meeting. Chapters were represented by Jay Goldman, St. Louis; Tom Woolard, Chicago; Joe Lloyd, Twin City; Clarence Allen, Milwaukee; Lewis Rose, Calumet; L. J. Fletcher, Central Illinois; Evan De Jong, Evansville; and Henry Messer, Kansas City.

MISSISSIPPI VALLEY CHAPTER

Over 200 participants attended the sixth Annual Winter Conference presented by the Mississippi Valley Chapter of AIIE on December 5, 1959. The Conference, "Selling Ideas" attracted people within a 150 mile radius of the quad-city area of Illinois and Iowa. Also present to view the proceedings was Mr. Arthur Aronson, Vice President of Region VIII, AIIE.

The conference theme "Selling Ideas" was divided into three sessions. The first, "Developing New and Improved Products," was presented by Mr. James W. Bannon, partner in the consulting firm of Booz, Allen, and Hamilton, Chicago, Illinois. The second, "Create a Market," was discussed by Mr. Travis Elliott of the National Restaurant Association, Texarkana, Texas. Mr. Elliott's talk examined the aspects of proper atmosphere in intercompany relations and integrity in dealings between people. An interesting and searching thought was presented wherein Mr. Elliott condemned the philosophy . . . "make him think it's his idea, it has a better chance of being accepted." . . . Ideas are sold on merit and not on who was fortunate enough to generate it, is Mr. Elliott's feeling.

The third, "Get Off Your Launching Pad," was a humorous approach to human relations presented by Dr. Carl C. Byers, who is a consultant for the General Motors Corporation. "A Happy Heart is as Essential to Success as is a Serious Mind" is Dr. Byer's key to providing the incentive necessary for complete participation by all company levels.

This conference, the sixth in a series which began back in 1955, followed the trend of thought-provoking seminars which was opened with Creative Thinking in 1957 and continued with Cost Reduction—My Job in 1958. The all-day meetings are conducted in the Masonic Temple, Davenport, Iowa and for the past several years have attracted executive and engineering people from business, industry and government located in that highly industrialized area. Plans are already being formulated for next year's meeting which has always been the highlight of the Chapter's yearly activities.

METROPOLITAN NEW JERSEY CHAPTER

At our November meeting, Dr. William Gomberg, Chief Industrial Engineer for the International Ladies Garment Workers Union and author of many books and papers on application of Industrial Engineering, was our speaker. Dr. Gomberg discussed "Work Rules Issues in Current Contract Negotiations." Prior to Dr. Gomberg's speech, we saw a film entitled "A Product of the Imagination." This was the story of aluminum from the dawn of time through its uses in the world of tomorrow.

In December our chapter held a banquet. Frank J. Johnson, National President of AIIE, was guest of honor and speaker for the evening. Mr. Johnson spoke to us on "Producibility Analysis—A Challenge to IE."

METROPOLITAN NEW YORK CHAPTER

The Metropolitan New York Chapter recently announced that it has exceeded its quota for the United Engineering Center Building Fund.

As an outcome of the successful fund raising drive, the Chapter has pledged a total of $6100 to the U.E.C. This figure is 102% of its original quota.

Congratulations to Mr. Robert Gring, Chairman of the Drive, and to the seventy-five contributing members.

ST. LOUIS CHAPTER

The St. Louis Chapter started off the 1959-60 season with some new ideas and an excellent program. With the membership figure beyond the 200 mark, and with fine attendance at the first four meetings, this should be a banner year.

The August meeting was held at the famous Barth Estate in St. Louis County. The festivities included swimming, ping-pong, "bull sessions" and a picnic supper on the huge porch.

The September meeting was the first of our dinner-speaker meetings. The Chapter was fortunate in having Dean Don Fischer of the Washington University School of Engineering speak on the "Crisis in Engineering." Dean Fischer spoke of the downturn in engineering enrollment in 1958, and of some of the critical issues facing the engineering profession and schools at this time.

Dr. Gerald Nadler, Head of the Department of Industrial Engineering at Washington University, was the principal speaker at the October meeting. Dr. Nadler had just returned from a 9-month teaching and research trip to Europe. He broke his talk down into a few main topics, and discussed each topic from the viewpoint of how it could be handled in the U.S.A. and in England. Dr. Nadler had some interesting comments to make on the European Industrial Engineering student as compared with his American counterpart.

The November meeting featured Dr. Hyman Meltzer, Director of Human Relations with the Orchard Paper Co. in St. Louis. His topic was "Personality and Human Management in Industry." Dr. Meltzer spoke of the "characters" in industry, and why everyone to some extent falls into that classification.

A new feature of our 1959-60 season has been the inauguration of seminars preceding the dinner meeting. These hour-long seminars deal with some practical problem in the field of Industrial Engineering. The topic for the October seminar was "Practical Problems Concerning Leveling." In November the topic was "What Can We Do with Non-Repetitive Items?"

YOUNGSTOWN CHAPTER

Our November meeting was a plant visitation to the Westinghouse Electric Transformer Division. This plant builds the largest power transformers in the world. The plant tour included the large power assembly and tank aisles, the mass production lines of distribution and instrument transformers. It was most interesting and informative to all members who attended.

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ENGINEERING MATERIALS HANDBOOK

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Newark College of Engineering. *1906 pp., 648 illus., $21.50*

Each of the 43 sections was prepared by one or more specialists. A staff of 150 of these experts cover metals, organic materials, and inorganic materials. Emphasis is placed on the fabricated forms of materials, their physical and mechanical properties, their adaptations, advantages, limitations, competition with each other, protection against deterioration, and increase in their stability to withstand use and abuse.

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Atlanta 13, Georgia

ie opportunities

WHAT IT IS

The I.E. Opportunities service is a functional committee activity of the AIIE. Information concerning employment opportunities is collected on a nationwide basis and is provided without charge to members upon request. The committee is composed of members from the Columbus, Ohio chapter.

SERVICES PROVIDED

Current job openings are published in condensed form in each issue.

In addition, a monthly I. E. Opportunities Bulletin is supplied to over one hundred chapters located throughout the United States.

Each job opening is assigned a **"P"** number for identification. The name and address of the person to contact for additional information concerning a specific job opening is sent to members on request.

EMPLOYERS

Employers having openings for qualified Industrial Engineers are invited to list them. Government agencies and educational institutions as well as business and industry are urged to take advantage of this free service.

Industrial Engineers are often employed in such fields as Work Measurement, Production Control, Plant Engineering, Operations Research, Industrial Relations, Sales, and Management. For a more complete coverage, see the following list of job classifications. Please do not hesitate to forward information on jobs in any area where it is recognized that an Industrial Engineering background will be of value.

To list your job openings with the Opportunities Service, send all or part of the following information with the name of your contact man to the address below: Type of industry, location, job classifications, minimum educational and experience qualifications, and salary range.

This information will be publicized to the members in condensed form in the JOURNAL and in monthly chapter Bulletins. Company names are not shown.

MEMBERS SEEKING JOB OPPORTUNITIES

The following list shows job openings available just prior to press time. If you would like more information about one or more of the positions listed, mail the **"P"** numbers with your name and address to the Opportunities Service at the address below. The Service will advise you by return mail of the name and address of the person to contact for further information, or advise you if the position is no longer available. Your name will not be forwarded to the company with the job opening.

For more current listings, contact your local Chapter Secretary or Opportunities Chairman for the latest monthly Bulletin.

ADDRESS OF THE SERVICE

I. E. OPPORTUNITIES SERVICE
American Institute of Industrial Engineers
145 North High Street
Columbus 15, Ohio

INDUSTRIAL ENGINEERING OPPORTUNITIES

Position number	Industry, location		Travel?	Job classification number (See key)	Salary range $1,000	Qualifications required		Remarks
						Years of exp.	Age range	
41	Consulting	Ohio	×	10, 21, 31		5–7		
167	Weapons Systems	Wash. D.C.		50				Ph.D.
213	Air Force	Calif.		15, 32, 42, 43, 44, 53	7.5–	2½–	21–	Repair & Modification
273	Air Force	Utah		11, 13, 18, 42, 43, 44, 53	6.3– 7.5	2–		I.E. Degree
279	Air Line	Ill., Colo., Calif.		11, 13, 18, 41–43, 50–52, 70	5.0– 8.5	1–6		
308	Automotive	Pa.		19, 31, 36, 38, 45, 53, 71	6.7– 9.7	3–7		
339	Automotive	Pa.		10, 22, 23, 32, 33, 36, 38, 42, 45, 71	6.7– 9.7	3–7		
340	Automotive	Pa.		11, 13, 22, 23, 32	5.5– 7.9	0–3		
376	Education	Mass.					35–	
419	Food Processing	Ill.		14, 15, 16, 22, 36, 38, 91	7.2– 9.0	5–8	30–38	I.E. or M.E. Degree
423	Air Force	Ohio		Broad	8.8			I.E. Degree
424	Air Force	Ohio		Broad	4.5– 7.5			I.E. Degree
447	Synthetic Fibers	W.Va.		10, 20, 30, 91	Open	3–5		I.E. Degree
449	Electronics	Mass.		30, 50, 70	6.0– 8.0	1–5		
461	Paper	Ohio	Ltd.	10, 20	9.0–13.0	3–5	–45	Tech. Deg. Req.
464	Consulting	N.J.	×	10, 20, 32–34, 42, 43, 54, 71–73, 92	8.0–12.0	5–	30–36	I.E. Degree
465	Consulting	Mass.	×	10, 20, 30, 40, 60, 71, 92	11.0–15.0	5–	35–45	I.E. Degree or Equiv.
470	Mining & Smelt .	N.M.		11, 13, 26, 36, 42, 45	5.0–7.0		–45	I.E. Degree Preferred
471	Plastic Prod.	Va.		10	10.0–12.0	5–	30–45	MTM Experience
472	Plastic Prod.	Va.		11	8.0– 8.5	1–2	–30	MTM Experience (Woodworking)
473	Electronics	Iowa		19, 30, 40, 50	7.2–	0–10		B.S. or M.S. Degree
474	Food Processing	Ill.		14, 15, 16, 22, 36, 38, 91	5.8– 9.0	0–8	25–35	I.E. or M.E. Degree
476	Metalworking	Ohio		13, 15, 36, 37	7.0–	2–5	25–30	
477	Metalworking	Ohio		53		2–5	25–30	
479	Brass Products	Conn.		10, 20, 36		1–5		Math. Experience
487	Electronics	Tex.		11, 16, 30, 32, 36	6.0–8.5	1–5	24–35	I.E. Degree
489	Refining	Tex.			10.0–12.0	10–15		Exp. in Crude Oil Act.
491	Airline	Ill., Colo., Calif.	15%	11, 13, 18, 51, 70	5.0– 8.0	1–5	–40	I.E. Degree Pref.
493	Plumbing Supplies	Ohio		11, 13, 18	7.5– 9.0	7–	30–35	I.E. Degree
494	Electronics	Utah		10–18, 34, 36, 40–46, 91	7.5– 9.0	5–10	30–40	I.E. Degree
495	Education	Fla.		Asst. Professor	Open	5–	30–	M.S. or Ph.D. Pref.
499	Electronic Equip.	N.Y.		10, 36	Open	3–		I.E. Degree or Equiv.
503	Electronics	D.C.		30	9.1–11.7	5–		I.E. Degree
506	Railroad	Pa.		11, 13, 31, 36, 42, 43	5.7– 7.2	0–2	24–30	I.E. or I.M. Pref.
507	Railroad	Pa.		31–38, 51–53	7.2– 9.6	2–5	24–35	I.E. or I.M. Pref.
511	Pharmaceutical	Mich.		General		0–5		I.E. Degree
514	Air Force	Ohio	25%	12, 17, 18	8.8–10.0	4½–		B.S.I.E. or M.S.I.E.
515	Air Force	Ohio	25%	40	8.8–10.0	4½–		B.S.I.E. or M.S.I.E.
516	Air Force	Ohio	25%	32, 37	8.8–10.0	4½–		B.S.I.E. or M.S.I.E.
517	Air Force	Ohio	25%	10, 13, 16	8.8–10.0	4½–		B.S.I.E. or M.S.I.E.
518	Air Force	Ohio	25%	Broad I.E.	8.8–10.0	4½–		B.S.I.E. or M.S.I.E.
519	Automotive Parts	Mich.		10	6.0– 9.0	3–5		College Degree
520	Automotive Parts	Mich.		30	6.0– 9.0	3–5		College Degree
522	Ind. Fastenings	Ill.		11, 14, 15, 19, 36, 38, 43, 45, 71	6.0– 7.8	1–3	–35	
523	Utilities	D.C.		10, 13, 17, 37, 50	5.7–	0–	25–	I.E. Degree
524	Utilities	D.C.		10, 13, 17, 37	6.0– 7.0	2–3	28–	I.E. Degree
527	Consulting	Ind., Ill., Minn.	×	15, 22, 31, 41, 53, 91	9.0–12.0	10–	35–50	I.E. Degree Pref.

Position number	Industry, location		Travel?	Job classification number (See key)	Salary range $1,000	Qualifications required		
						Years of exp.	Age range	Remarks
528	Farm Cooperative	N.Y.	×	Broad	8.0– 9.0	5–7		I.E. Deg. Plus B.A. Train.
530	Paper Prod.	Mo.	×	15, 21, 36, 38, 42, 53, 54, 70	6.0–10.0	2–5	24–35	I.E. Degree
531	Consulting	Ohio	×	40, 50, 70, 80, 90	Open	5–15	25–40	B.S. Degree
532	Metal Fasteners	Pa.		11, 15, 19, 26	7.9– 9.0	5–10	28–40	
533	Chemical-Plastics	N.J.		31, 35	Open	4–	35–50	Prod.—Inv. Control Exp.
534	Glass	N.Y.	½	11, 42, 43, 44, 45, 46, 47	7.0–	5–	30–40	I.E. or M.E. Degree
537	Printing-Litho.	Wis.		10, 20, 30, 70	8.0–	3–10		
538	Papermaking	Pa.		50, 51, 52, 53, 55	9.0–11.0	3–5	25–35	
539	U. S. Army	Ill.	×	37, 52, 54	7.5–11.0	2–4		B.S. Degree
541	Communications Mfg.	N.Y.		13, 43, 81	7.5– 9.5	3–	30–40	I.E. Degree or Equiv.
542	Electronics	N.Y.		19, 42, 43	5.2– 8.5	0–3		B.S.—I.E., I.M., or M.E.
543	Air Force (Maint.)	Pa.		11, 13, 18, 44, 53, 91	7.5	4–	25–40	I.E. Degree
544	Consulting	Ill.		50–54	7.5–11.0	0–5	21–35	Adv. Degree Pref.
545	Consulting	Pa.	×	Broad	8.0–12.0	5–	28–45	
546	Consulting	Ill.	½	Broad	8.0–12.0	5–	28–40	
547	Home Appliances	Ohio		11, 13, 16, 21, 36	7.2– 9.6	4–6	25–35	I.E. Degree—Mtm. Exp.
552	Smelt. & Titanium	Canada			7.0– 8.5	5–10		
553	Sugar Refining	Mass., Md., La.		11, 36, 38, 43	6.2–	0–5		I.E. Degree
554	Auto. Elect. Electro-Mechanical Equipment	Midwest		10, 32, 42	15.0–20.0		38–46	E.E., M.E., or I.E. Degree
555	Office Machy.	Mich.		11, 30–37	9.6–	3–	30–40	Exp. in System Analysis
556	Office Machy.	Mich.		30	9.6–	3–5		Exp. in Quality Control
557	Corrugated Boxes	Tex.		10, 21–23, 26, 42, 60	6.0–	2–3	23–34	I.E. Degree
558	Food Processing	Minn.		36, 38		2–		I.E. or I.M. Degree
559	Machine Tool Mfg.	Wis.		Project Engineer	Open	0–3	Open	B.S.M.E. or I.E. Equiv.
560	Machine Tool Mfg.	Wis.		Tool Designer	Open	3–5	Open	Degree not Necessary
561	Navy	S.C.		11, 15, 17, 18, 52, 71, 90	7.5– 8.2	2½–		Degree
562	Education	Ariz.		50–52, 54	Open	Open	Open	M.S.
563	Needles	Mo.		92	9.0–10.0	8–10	30–	College Graduate
564	Education	N.D.		30, 40, 50	7.0–	8–	40–50	M.S./Ph.D. or P.E.
565	Structural Clay Prod.	Tex.	×	11, 35–37, 41–43, 49, 53, 71, 92	9.0–11.0	8–12	30–42	B.S.I.E.
566	Education	Mo.		10, 30, 40, 50	Open			
567	Lumbering Mfg.-Cut Parts	La.		10, 30, 32, 33, 40, 48, 94	4.5– 6.5		25–40	
568	Motor Freight	Minn.		43, 81	8.0–12.0	5–10	30–40	Degree in I.E. Pref.
569	Transportation *(See Below)			10, 30, 42, 43, 47	8.4– 9.6	7–	30–	I.E. Degree
570	Transportation *(See Below)			10, 30, 42, 43, 47	7.0– 8.4	4–	20–	I.E. Degree
571	Transportation *(See Below)			10, 30, 42, 43, 47	6.0–	None	20–	I.E. Degree
572	Mgmt. Consultant	U.S.A. & Europe	×	10, 11, 13–18, 21, 22, 91 or 92	Open	5–	30–40	MTM Experience
573	Consulting	Ohio	Ltd.	10, 20, 30, 40, 50	Open	3–	25–	P.E. or E.I.T.
574	Aircraft Parts—(Mach.)	N.J.		10, 11, 13–16, 18, 36, 91	9.0–12.0	8–12	32–45	Engineering Degree
575	Specialty Papers	Mass.		11, 21, 36, 38, 41, 43, 67, 92	7.0–10.0	6–8	30–40	I.E. Deg.—Paper Ind. Exp.
576	Hospital (Teaching)	Calif.		12, 18	7.2– 7.8			
577	Meat Packing	Minn.		10, 11, 13, 22, 38	5.0–	0–2	–30	I.E., M.E., or B.S. Degree
578	Education	Ohio		50–54			Open	M.S./Ph.D.—M.E., I.E., or Applied Math.
579	Pharmaceutical	Ill.		36		3–5		I.E. Degree or Equiv.
580	Solid Propellants	Tex.		11, 12, 19, 32, 34, 41–43, 53	7.0–10.3	2–4	25–35	B.S. in I.E. or M.E. Pref.
581	Paper	Ga.		11, 13, 21, 42 (91 or 92 Exp.)	12.0–15.0	3–	35–48	M.S.I.E. Pref., B.S.I.E. Accep.
582	Paper	Ga.		43	7.5– 8.5		30–40	B.S. in I.E. or I.M.
583	Plastic Molding	Mass.		11, 13–16, 18, 22, 42	7.2–			I.E. Degree
584	Chemical	Pa., W.Va.		11, 18, 38, 52	7.0–	3–	25–	B.S. Degree
585	Garment Mfg.	N.J.		10	5.2– 5.7	0–2		I.E. Degree
586	Glass Containers	Ind.		10, 11, 13, 14, 16, 21, 31, 36	6.3– 7.2	2–5	22–32	
587	Naval Avionics	Ind.		11, 30, 40, 70	6.2– 7.5	2–4		I.E. Degree
588	Printing	Ohio		10, 20, 30, 40, 42, 43	Open	2–7	–30	I.E. or M.E. Degree
589	Semiconductors	Ariz.		11, 12, 15, 18, 19, 26, 36	6.0–10.0	2–5	25–35	B.S. Pref.
590	Semiconductors	Ariz.		42, 43	6.0–10.0	2–5	25–35	B.S. Pref.
591	Semiconductors	Ariz.		66	6.0–10.0	2–5	25–35	B.S. Pref.
592	Paper Converting	Ohio		10–19, 36, 38, 40–49, 53	6.3– 9.0	Open	Open	I.E. or M.E. Degree
593	Metal Working	Mich.		10, 11, 13, 20, 39, 42	10.0–	10–		Engineering Degree
594	Chemical Mfg.	Tex.		11, 30, 32, 34, 43	7.0– 9.5	2–6	27–40	B.S.I.E.
595	Plastics	Ill.		11, 42–46	7.2– 8.4	5–		B.S.M.E. or B.S.I.E.
596	Mining & Refining	Ariz.		11–13, 18, 26, 28, 35, 36, 38, 48	6.5– 9.0		–40	
597	Needle-Plastics	Dela.		11, 14, 15, 19, 22, 26, 42, 48, 91	7.9– 9.5	4–	28–35	B.S.I.E. or B.S.M.E.
598	Needle-Plastics	Dela.		31, 33, 35, 36, 43, 71, 73, 91	7.9– 9.5	4–	28–35	B.S.I.E. or B.S.M.E.
599	Nonferrous Metal Fabr.	Conn.		10–14, 17, 18, 20–22	5.0– 7.0	Open	Open	I.E. Degree Preferred
600	Rubber	Pa.		11, 13, 16, 21, 36	6.0– 7.2	3–5	28–45	
601	Wood and Plastics	Va.		21	7.5– 8.0	2–3	25–35	B.S. Degree
602	Education-Teaching	Mich.		13–16, 18	7.0–	3–5	25–50	B.S., M.S., or Ph.D. in I.E. or M.E.
603	Education	Mich.		30—in Die Casting or Plastics	7.0–	3–5	25–50	Same as above
604	Education	Mich.		30—in Metal Cutting	7.0–	3–5	25–50	Same as above
605	Education	Mich.		39	7.0–	3–5	25–50	Same as above
606	Education	Mich.		50–54	7.0–	3–5	25–50	Same as above
607	Elect. Controls	Mass.		92	10.0–12.0	5–10	–40	I.E. or M.E. Degree
608	Elect. Controls	Mass.		Production Engineer	6.5– 8.5	2–3	25–35	I.E. Deg. with Electronic or Prec. Mech. Assy. Exp.
609	Research & Devel.	Md.		30, 40, 42		8–		B.S.I.E.
610	Research & Devel.	Md.		30		5–		B.S.I.E.
611	Research & Devel.	Md.		30		3–		B.S.I.E.
612	Bearings	Mich.		10, 22, 42, 91	8.5–10.0	10–	30–40	I.E. or Bus. Deg. Pref.
613	Electronics	Utah		10–18, 34, 36, 40–46, 81, 91	7.5– 9.0	5–10	30–40	I.E. Degree
614	Electronic	Iowa		92, 10, 42, 30	7.5–10.0	5–10		I.E., M.E. or E.E. Deg.
615	Heat Trans. Equip. Mfg.	Wis.		11, 14, 15, 19, 32, 38	6.6–	3–	–35	B.S.I.E. Pref.
616	Elect. Mech. Instr.	Iowa		92	10.0–13.0			B.S.I.E.
617	Steel Goods Mfg.	N.M.		11, 31, 35, 54, 70	6.0– 8.0	3–5		I.E. Degree
618	Metalworking	Ohio		10, 11, 19, 32	Open	8		B.S.I.E.
619	Metal Casting & Machy.	Minn.		10, 30, 40, 44, 92	9.0–12.0	8–		B.S.M.E.
620	Food Machy. Mfg.	Iowa		36, 42, 43	6.0– 8.0	5–		M.E. Deg. or 2–3 Yrs. Col.

* The above 3 P's have openings in New York City, Detroit, Mich., Syracuse, N. Y., Indianapolis, Ind., and Cleveland, Ohio

Key to Job Classifications

No.	Job Classification
10	Motion and Time Study
11	Methods Improvement
12	Suggestion Systems
13	Work Measurement and Perf. Stds.
14	Stop Watch Time Study
15	Std. Time Data Dev. & Applic.
16	Predeter. Elemental Time Stds.
18	Work Sampling
19	Estimating and Costing
20	Wage Payment
21	Incentive Plans
22	For Production Workers
23	For Non-Prod. Workers
24	For Supervisory Personnel
26	Job Evaluation
28	Wage Administration
30	Production Engineering
31	Production Control
32	Process Planning and Routing
33	Scheduling and Loading
34	Flow Process Charting
35	Inventory Control
36	Cost Anal. & Reduction
37	Statistical Quality Control
38	Budgetary Control, Standard Costs
39	Tool and Gage Design and Control
40	Plant Engineering
41	Plant Location & Expansion
42	Plant Layout
43	Material Handling
44	Machinery & Equipment
45	Specif., Select. & Eval.
46	Replacement
47	Automation
48	Plant Maintenance
49	Cap. Budget. Facil. Plan
50	Operations Research
51	System & Simulation with "Models"
52	Mathematical Analysis
53	Engr. Economy Studies
54	Auto. Data Proc. with Computers
55	Market Research & Forecasting
60	Industrial Relations
61	Personnel Administration
62	Personnel Testing
63	Personnel Training
64	Industrial Psychology
65	Labor Relations
66	Safety Engineering
67	Suggestion Systems
70	Systems and Procedures
71	Admin. & Operating Procedures
72	Organization Charts and Manuals
73	Records Admin. & Form Control
80	Product Design
81	Packaging
90	Management and Supervision
91	Industrial Engineering Supr.
92	Chief I. E. or Equiv.
93	Plant Engineer
94	Production Supervisor
95	Plant Mgr., Fact. Mgr., Works Mgr.
96	General Manager

AIIE Membership Roster*

November 1, 1959

Marcis, George, 2064 Clarence Avenue, Lakewood 7, Ohio *7A-2*
Marcone, Arthur W., 487 Judith Lane, Struthers, Ohio *24A-1*
Marcouiller, Robert J., 3204 West Wells Street, Milwaukee 8, Wisconsin *45A-2*
Marcus, Harold J., 11546 Babbitt Avenue, Granada Hills, California *23M-4*
Marcus, Joel A., 69-61 Yellowstone Boulevard, Forest Hills 75, Queens, New York *5A-2*
Mardis, Robert Lynn, 1622 Centerridge Avenue, Cincinnati 31, Ohio *8M-4*
Margeson, Clarence R., Box 21, Navy 230, c/o Postmaster, Seattle, Washington *0AF-3*
Margeson, De Forest M., 515 Carl Street, Endicott, New York *96A-1*
Margolin, Charles H., 54 Flamehill Road, Levittown, Pennsylvania *77A-2*
Margolis, Sidney O., 76-09 Thirty-fourth Avenue, Jackson Heights 72, New York *5A-4*
Margoshes, Herbert M., 34 Marion Road, Marblehead, Massachusetts *30M-4*
Mariano, Remo P., 302 Billings Road, Quincy, Massachusetts *30A-2*
Markowski, M. J., 18206 Windward Road, Cleveland 19, Ohio *7M-4*
Marks, Alan D., 1507 Gordon Street, Redwood City, California *12A-2*
Marks, A. R., The Martin Company, Box 179, Denver, Colorado *32A-1*
Marks, Everett J., 176 Fifth Avenue, New Rochelle, New York *5A-2*
Marks, Gerald R., 50 Brompton Road, Great Neck, New York *86A-2*
Marks, Robert J., A. O. Smith Corporation, 3533 North Twenty-seventh Street, Milwaukee, Wisconsin *45M-4*
Marks, Stuart T., Box 165, Summerville, Georgia *93AF-4*
Marlin, Norman H., Jr., Warner-Chilcott Laboratories, Tabor Road, Morris Plains, New Jersey *61A-2*
Marlow, James C., Jr., 2428 Westminster Way, N.E., Atlanta 7, Georgia *6A-2*
Marlowe, Warren J., 4103 Sulgrave Road, Richmond 21, Virginia *99A-2*
Maron, Henry E., 305 North Datura, Littleton, Colorado *32A-1*
Marquis, Leland G., Main Street, West Stockbridge, Massachusetts *0A-1*
Marquis, William R., United States Steel Corporation, Homestead District Works, Munhall, Pennsylvania *3M-3*
Marr, Phillip W., 4515 St. Margaret Lane, Columbus 13, Ohio *1A-2*
Marra, Joseph G., 256 Hickory Street, Washington Township, Westwood, New Jersey *5A-4*
Marrinan, William K., R.R. 1, St. Paul 11, Minnesota *38A-2*
Marshall, Clayton F., 205 Carmel Avenue, Galion, Ohio *0M-3*
Marshall, Fred E., 1307 Revere Road, Winston-Salem, North Carolina *21A-2*
Marshall, George L., Jr., 15534 East Dittmar Drive, Whittier, California *23M-4*
Martellotto, Peter A., 2117 Blackrock Avenue, Bronx 72, New York *5A-2*
Marthey, Louis G., 316 Union Street, Crawfordsville, Indiana *35A-2*
Marti, Edward A., Assistant Chief Industrial Engineer, The William Carter Company, 33 Morris Street, Springfield, Massachusetts *94A-2*
Martin, Charles E., 2836 Hermitage Drive, Winston-Salem, North Carolina *21A-2*
Martin, Floyd E., Jr., 851 Congress Avenue Extension, Waterbury, Connecticut *97A-2*
Martin, Frederick E., 236 East Pulteney Street, Corning, New York *48A-1*
Martin, George H., 123 Forest Street, Danvers, Massachusetts *30M-4*
Martin, Homer E., 228 Sandhurst Drive, Dayton 5, Ohio *2M-4*
Martin, Howard N., White Cap Company, 1819 North Major Avenue, Chicago 39, Illinois *25M-4*
Martin, John Richard, 178 Loveman Avenue, Worthington, Ohio *1A-4*
Martin, John T., 3005 Ford Avenue, Pittsburgh 35, Pennsylvania *3M-3*
Martin, Joseph B., 909 Glencrest, Longview, Texas *60A-2*
Martin, Joseph D., 2350 Nineteenth, Wyandotte, Michigan *47A-2*
Martin, Kenneth W., 1359 Overlook Terrace, Titusville, Florida *0A-1*
Martin, Raymond M., 6231 Coolidge Road, Dearborn, Michigan *47A-2*
Martin, Richard A., P.O. Box 27, Southbridge, Massachusetts *68A-2*
Martin, Robert J., 8025 West Lake Street, River Forest, Illinois *25A-1*
Martin, William L., 2106 Erbbe Street, Albuquerque, N.E., New Mexico *59A-1*
Martin, Wyatt L., Jr., Box 158, Winston-Salem, North Carolina *21A-2*
Martinelli, William R., United States Time Corporation, Middlebury, Connecticut *97A-2*
Martinez, Anthony F., 11 University Place, Great Neck, Long Island, New York *86A-2*
Martinko, Frank W., 610 Michigan Avenue, Glassport, Pennsylvania *3A-1*
Martinson, E. P., Department of Industrial Engineering, University of Florida, Gainesville, Florida *27M-4*
Martz, Kenneth T., Eli Lilly and Company, 740 South Alabama Street, Indianapolis 6, Indiana *65A-2*
Martzloff, Thomas H., c/o McKinsey and Company, Russ Building, 235 Montgomery Street, San Francisco 4, California *37M-4*
Marum, Harald, 73 Morris Avenue, Haworth, New Jersey *5M-4*
Maruszewski, Bernard J., 621 Juniper Circle, South Milwaukee, Wisconsin *45M-4*
Marville, F. Edwin, 119 Maple Avenue, Willow Grove, Pennsylvania *31M-4*
Marx, John B., 1300 Cotton Street, Menlo Park, California *37M-4*
Marye, Robert, 204 Dawn Street, Signal Mountain, Tennessee *54M-4*
Marzo, A. S., 1320 Alexander, S.E., Grand Rapids 6, Michigan *0AF-3*
Mascarin, A. Edward, 2164 Fourteenth Avenue, Kingsburg, California *0A-1*
Mason, Carrington, P.O. Box 1188, Houston 1, Texas *22M-4*
Mason, Harold, 52 Brighton Second Lane, Brooklyn 35, New York *5A-4*
Mason, Hubert E., 912 West College, Oakland City, Indiana *88AF-4*
Mason, Jack F., 1421 Oakwood Trail, Indianapolis 20, Indiana *65M-4*

* The first portion of the roster was published in the January-February issue. If errors in names and addresses are found, notify AIIE Headquarters in Columbus, Ohio, in order that records may be corrected.

Mason, Richard P., 102 Malwood Avenue, Dracut, Massachusetts *62A-2*
Massa, John A., 35 Moore Street, Winthrop 52, Massachusetts *30A-2*
Massey, Ed C., 2272 Miller Field Road, Macon, Georgia *55A-1*
Massey, James W., 147 North Rampart Boulevard, Los Angeles 26, California *23A-1*
Masson, Daniel John, 900 South Avenue "C", Washington, Iowa *0A-1*
Masters, Lawrence T., 5 Madill Court, Antioch, California *12A-2*
Masters, Robert H., Ohio Power Company, Canton 1, Ohio *19M-3*
Mastrangelo, Paul L., 33299 Guilbert Drive, Willoughby, Ohio *7A-2*
Masucci, Robert J., 2105 Shady Lane Drive, Huntsville, Alabama *69A-2*
Matheny, Herschel A., Route 2, Guntersville, Alabama *69A-2*
Mathes, Charles F., Standard Coosa Thatcher Company, P.O. Box 791, Chattanooga 1, Tennessee *54A-2*
Mathes, Charles J., 24414 Farmington Road, Farmington, Michigan *47A-2*
Mathews, George, 2573 Hyde Street, Burlington, North Carolina *66A-1*
Mathews, Harold H., Jr., R. J. Reynolds Tobacco Company, Industrial Engineering Department, Winston-Salem, North Carolina *21M-4*
Mathews, Howard H., Jr., 121 West Thirty-sixth Avenue, San Mateo, California *37A-1*
Mathewson, M. H., Industrial Engineering Department, International Mining and Chemical Corporation, Administration Center, Old Orchard Road, Skokie, Illinois *25M-4*
Mathis, Mark C., Jr., USS Wyandot (AKA-42), c/o Fleet Post Office, New York, New York *5A-2*
Matosoff, Henry, 1045 Lavender Lane, Route 2, LaCanada, California *23A-3*
Matreci, Eugene R., 7900 Delmar, University City, Missouri *16A-2*
Matschke, Arthur L., Jr., 605 East Maple Avenue, Mundelein, Illinois *25A-1*
Matson, William C., 2368 Victory Parkway, Cincinnati 6, Ohio *8A-2*
Mattern, Philip J., Eaton Metal Products Corporation, 1301 Willis Avenue, Omaha 10, Nebraska *90AF-1*
Matthew, Theodore B., 400 Old Spanish Trail, Menlo Park, California *37A-1*
Matthews, Alan H., 744 Elizabeth Street, Baton Rouge, Louisiana *41M-3*
Matthews, Ansel H., 1204 Holland Street, Cumberland, Maryland *0M-3*
Matthews, Courtney, Charles Luckman Associates, 9220 Sunset Boulevard, Los Angeles 46, California *23A-1*
Matthews, Don Q., 7449 East Thirty-first Street, Tulsa 5, Oklahoma *15M-3*
Matthews, Donald M., 4 Delsing Drive, Rexdale, Ontario, Canada *87A-1*
Matthews, Gene A., Route 1, Carrollton, Alabama *0AF-3*
Matthews, Robert D., Assistant Industrial Engineer, International Nickel Company, Huntington, West Virginia *58A-2*
Matthews, Walter D., 937 Second Street, N.E., Massillon, Ohio *19A-1*
Matthews, William C., c/o Lenkurt Electric Company, Incorporated, 1105 County Road, San Carlos, California *37A-1*
Mattice, Dudley R., P.O. Box 621, Wailuku, Maui, Hawaii *0A-1*
Mattocks, Raymond E., Olin Mathieson Chemical Corporation, East Alton, Illinois *16M-1*
Matuch, George, Jr., 5415 Gable Lane, Jacksonville 11, Florida *27M-4*
Matus, Joseph A., 1404 Churchill Road, Lyndhurst 3, Ohio *7M-4*
Matusiak, Edward J., Mine Safety Appliances Company, 7501 Penn Avenue, Pittsburgh, Pennsylvania *3A-1*
Matusik, Edward J., 1943 Chestnut Street, Harrisburg, Pennsylvania *95M-4*
Maurer, Henry L., 1630 West Seventh Avenue, Gary, Indiana *53M-3*
Maurer, John L., R.R. 1, Town Line Road, North Madison, Ohio *7M-4*
Maurer, Robert M., 11204 Mahlon Avenue, N.E., Albuquerque, New Mexico *59M-3*
Mause, Clifford H., 5029 West Boulevard, Canton 8, Ohio *19M-3*
Mauthe, John G., Jr., 3197 Ameno Road, Concord, California *12A-2*
Mawson, Richard W., Eastman Kodak Company, 1669 Lake Avenue, Rochester 4, New York *44A-2*
Maxwell, C. Herbert, Box 550, R.D. 1, Masury, Ohio *24M-3*
Maxwell, George W., 908 Marlau Drive, Baltimore 12, Maryland *42A-2*
Maxwell, Herris M., Route 2, Broadhead Road, Bethlehem, Pennsylvania *77M-4*
Maxwell, Ralph, Jr., 312 River Oaks Drive, New Orleans 14, Louisiana *74M-4*
Maxwell, Robert J., Toledo Scale Company, Telegraph Road, Toledo 13, Ohio *36A-2*
Maxwell, Warren A., 3535 Dayton Avenue, Louisville 7, Kentucky *18M-3*
Maxwell, William A., E. Kahn's and Sons, 3241 Spring Grove Avenue, Cincinnati 25, Ohio *8A-2*
Maxwell, William J., 1430 Burtner Road, Natrona Heights, Pennsylvania *3A-1*
May, Arthur R., Sterling Casting Corporation, Bluffton, Indiana *34A-1*
May, Carl P., 3 Enright Avenue, Jeffersonville, Indiana *18A-3*
May, Christie M., Jr., 35 Market Street, Lewisburg, Pennsylvania *89M-3*
May, Harold H., 630 Mt. Zoar, Elmira, New York *48M-3*
May, James E., Bangs, Texas *0A-1*
May, Walter C., 10412 Viscount Drive, St. Louis 21, Missouri *16A-2*
May, William C., 73 Grandview Place, Walnut Creek, California *12A-2*
Mayberry, Frank P., 2019 Valley View Road, Sharpsville, Pennsylvania *24M-3*
Mayberry, Hassell G., 3051 Gilmer Avenue, Winston-Salem, North Carolina *21A-2*
Mayem, Morris, 16 Ocean Parkway, Brooklyn 18, New York *5A-2*
Mayer, Donald A., 722 Panchita Way, Los Altos, California *37M-4*
Mayer, Mitchell L., 20 Crosby Avenue, Deal, New Jersey *61A-2*
Mayer, Robert L., 250 Woodward Street, Wavan 68, Massachusetts *30M-4*
Mayer, Victor P., 493 Dale Drive, Erie, Pennsylvania *51M-4*
Mayers, Robert G., 16½ Andrew Street, Kingston, New York *76A-2*
Mayhew, Rodney D., Armstrong Cork Company, Linoleum Plant, Liberty Street, Lancaster, Pennsylvania *71M-4*
Maynard, Harold B., Methods Engineering Council, 718 Wallace Avenue, Pittsburgh 21, Pennsylvania *3M-3*
Maynard, James M., R.F.D., Box 290, Tooele, Utah *50A-2*
Maynard, Miles J., 209 Jackson Circle, Tullahoma, Tennessee *64A-1*
Mayo, William E., Route 2, Brighton, Tennessee *0A-1*
Mayr, William F., II, Sault Ste. Marie, AD Sector, KI Sawyer Air Force Base, Gwinn, Michigan *0A-1*
Mays, Carl L., 704 Sixth Street, Fremont, Ohio *36A-2*
Mays, Henry E., 1002 Claudine, N.E., Albuquerque, New Mexico *59A-1*
Mazeika, Daniel F., YMCA—304 Wood Street, Pittsburgh 22, Pennsylvania *3A-1*
Mazich, Paul, 301 South Clover Lane, Harrisburg, Pennsylvania *95A-2*
Mazura, Louis V., R.D. 1, State Road, Meadville, Pennsylvania *51AF-4*
Mead, George G., 721 Walnut Street, Latrobe, Pennsylvania *3M-3*
Mead, Gordon S., 310 Lorraine Drive (R.F.D. 1), Pickerington, Ohio *1A-4*
Meade, Clyde B., 237 Buchanan, Fayetteville, Arkansas *84A-1*
Meade, Donald F., 454 North Almont Drive, Los Angeles 48, California *23A-1*

Meador, Norman W., 3914 Olympia Drive, Winston-Salem, North Carolina *21A-2*
Means, M. Frank, 1320-D East Thirty-eighth Street, Tulsa 5, Oklahoma *15M-3*
Mears, Francis C., R.D. 2, West Lockhart Street, Sayre, Pennsylvania *48A-1*
Mears, Walter J., Chief Industrial Engineer, E Z Paintr, 4051 South Iowa Avenue, Milwaukee 7, Wisconsin *45AF-4*
Mecca, Mauro L., 29 Bowes Place, Passaic, New Jersey *61A-2*
Meckle, Franklin C., 1425 Haupt Avenue, Richland, Washington *0A-1*
Meckley, Daniel G., III, 602 Crescent Road, Mansfield, Ohio *0M-3*
Meckley, John S., 7416-B River Drive, Newport News, Virginia *99A-2*
Medford, J. Frederick, 8246 Roberts Drive, Dunwoody, Georgia *6M-4*
Medford, Lel L., Tyler Pipe and Foundry, P.O. Box 2027, Tyler, Texas *60AF-4*
Mediate, Anthony, 2355 Skywae Drive, Youngstown 11, Ohio *24A-1*
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Medwin, Julius M., 67-52 Two Hundred Eleventh Street, Bayside, New York *5M-4*
Meeder, Merle L., American Radiator and Standard Sanitary, 1541 South Seventh Street, Louisville 8, Kentucky *18M-3*
Megani, Peter S., 239 Pines Lake Drive, East, Wayne, New Jersey *61M-4*
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Mehta, Suresh J., 16 B Manheim Gardens, Philadelphia 44, Pennsylvania *31A-2*
Meier, Arnold R., American Blower, 8111 Tireman, Dearborn, Michigan *47A-2*
Meier, France A., 843 Georgia, Beaumont, Texas *0A-3*
Meier, Morris G., 207 Elliott Street, Austin, Texas *0A-1*
Meincer, John H., 1515 Holderby Road, Huntington 1, West Virginia *58M-4*
Meinert, Grover N., Atlantic Steel Company, P.O. Box 1714, Atlanta 1, Georgia *6M-4*
Meintel, Joseph E., Newell Road, R.F.D. 3, Schenectady 6, New York *0M-3*
Meisel, Seymour L., 229 Grayton Road, Tonawanda, New York *49M-3*
Melgaard, Eugene M., Code M211.2, United States Navy, Bureau of Yards and Docks, Washington 25, District of Columbia *14A-2*
Melligan, Grover W., Glen Gardner, New Jersey *77A-2*
Mellin, Warren Roger, United Air Lines, 5959 South Cicero Avenue, Chicago 38, Illinois *25M-4*
Meltzer, Alvin S., Fifth Ordnance Company (d/s) APO 358, San Francisco, California *0A-1*
Menard, Fred S., 3326 Poinsettia Drive, Dallas 11, Texas *10AF-3*
Mender, Charles A., 620 Sizeler Avenue, New Orleans 21, Louisiana *74A-2*
Mendler, Robert F., 224 Regency Road, Le Sueur, Minnesota *38M-4*
Meninger, Frank J., 42 Amherst Place, Livingston, New Jersey *61M-4*
Menke, Robert M., 528 Seventh Avenue, South, St. Petersburg, Florida *91A-2*
Menkemeller, Edward F., A Company, 27th ORD BN, 1st CAV, APO 24, San Francisco, California *0A-1*
Menten, Robert A., Allegheny Ludlum Steel Corporation, Oliver Building, Pittsburgh 22, Pennsylvania *3M-3*
Mentz, Philip Sherwood, 10544 Cletus Drive, Baton Rouge, Louisiana *41M-3*
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Merkel, Mary Rita, 123 Manor Parkway, Apartment 4, Rochester 20, New York *44M-4*
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Merrill, Karl R., 4632 Hastings Drive, Dayton 40, Ohio *2A-2*
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Merrithew, E. C., 6146th AF Advisory Gp., APO 76, San Francisco, California *0A-1*
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Mersch, Richard J., 174 West Ninth, San Bernardino, California *78A-2*
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Miller, Frank Nicholas, S. C. Johnson and Son, Incorporated, 1525 Howe Street, Racine, Wisconsin *45M-4*

Miller, Frederick H., 2653 South Twelfth Street, Milwaukee 15, Wisconsin *45A-2*

Miller, Gerhard, 44 Hudson Street, Bath, New York *48A-1*

Miller, Harry P., 110 Cornwall Lane, Rochester 17, New York *44M-4*

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Miller, Jack E., 11117 Blue Ridge Extension, Kansas City 34, Missouri *92A-2*

Miller, Jack T., 608 Griffith, Terrell, Texas *0A-1*

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Miller, James F., 5001 Lauderdale Drive, Dayton 39, Ohio *2A-2*

Miller, James P., 2139-A North John Russell Circle, Elkins Park 17, Pennsylvania *31A-2*

Miller, John C., 29 Norden Drive, Spring Hill, Alabama *79A-2*

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Miller, Malcolm F., 473 Prince Frederick Street, King of Prussia, Pennsylvania *31M-4*

Miller, Martin C., Rolling Acres, Chesterland, Ohio *7M-4*

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Miller, Reuben, 7721 Colfax, Chicago 49, Illinois *25A-3*

Miller, Richard N., 4929 Penrose, Ft. Worth, Texas *10A-1*

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Miller, Robert F., 206 East Stanton Avenue, Columbus 14, Ohio *1A-4*

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Miller, Samuel D., 511 Chelsea Avenue, Erie, Pennsylvania *51M-4*

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Miller, William O., Jr., 237 Marlin Road, Absecon, New Jersey *0A-1*
Miller, William R., 24445 Garden Drive, Euclid 23, Ohio *7A-4*
Miller, William R., 1125 Main Street, Massillon, Ohio *19A-1*
Milleson, Wilson E., Springfield, West Virginia *0A-1*
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Milligan, John E., 613 Julie Drive, Layton, Utah *50A-2*
Milliken, Don B., Box 619, Cary Hall, Purdue University, Lafayette, Indiana *35A-2*
Millis, Hugh A., 335 Piatt, Wichita 7, Kansas *56A-2*
Millner, Leonard J., 934 Greenwood Avenue, Trenton 9, New Jersey *31A-4*
Mills, James R., 9 Keeler Street, Rochester 21, New York *44A-2*
Mills, James W., 711 North East Olive, Newport, Oregon *67A-1*
Mills, Norman L., 10518 Londonderry Drive, Houston 24, Texas *22A-3*
Mills, Robert M., Jr., Mountain Road, RFD 3, Georgetown, Connecticut *82A-2*
Mills, William W., Jr., Industrial Engineering Division, Newport News Shipbuilding and Dry Dock Company, Newport News, Virginia *99A-2*
Milner, Donald Edward, Massey-Ferguson Limited, 915 King Street, W., Toronto 3, Ontario, Canada *87M-3*
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Minassian, Vasken S., 153 Manse Road, Hagerstown, Maryland *42A-2*
Minasy, Arthur J., 21 Elm Street, Woodbury, Long Island, New York *5M-4*
Miner, Donald Keith, 1075 Crandall Avenue, Salt Lake City, Utah *50A-2*
Miner, Donald S., Jr., 1912 East Denker, Wichita 16, Kansas *56A-2*
Miner, Ned B., 118 Royer Street, North Canton 20, Ohio *19A-1*
Miner, Warren P., Box 584, RFD 2, Batavia, New York *0A-1*
Minerath, Raymond A., 6625 South Pennsylvania, South Milwaukee, Wisconsin *45A-2*
Minich, Bobby L., Box 771, Friona, Texas *0A-1*
Minor, William J., 666 Union Street, Corry, Pennsylvania *51A-2*
Mintz, Stanton E., 17962 Valley Vista, Encino, California *23A-3*
Mintz, William A., 5021 Wood Street, La Mesa, California *23A-1*
Mirakian, Paul, Jr., 8126 Fourteenth Avenue, #1, West Hyattsville, Maryland *14A-4*
Miranda, James M., Chief Industrial Engineer, General Merchandising Company, 207 North Milwaukee Street, Milwaukee 1, Wisconsin *45A-2*
Missakian, Arys, 16 Chemin William Barbey, Chambesy, Geneva, Switzerland *0A-1*
Missell, William S., Third Street, New Freedom, Pennsylvania *72A-2*
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Mitchell, Edwin J., Jr., 23 Home Road, Hatboro, Pennsylvania *31A-2*
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Mitchell, Harlan D., 2204 Huntington, Arlington, Texas *10A-3*
Mitchell, James R., 501 Driving Park Avenue, Rochester 13, New York *44A-4*
Mitchell, Robert W., 372 Grand Avenue, Johnson City, New York *96A-1*
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Mize, Joe H., P.O. Box 1061, 507 West Fifth Street, Big Spring, Texas *0A-1*
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Monnett, Richard L., 16575 Heyden, Detroit 19, Michigan *47A-2*
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Moore, Charles K., 223 Gilpin Road, Willow Grove 4, Pennsylvania *31AF-4*
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Morrison, Doyle H., Ward, Arkansas *84A-1*

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O'Brien, James P., 60 Navajo Road, Springfield, Massachusetts *94A-2*
Ochterbeck, Donald W., 203 Archer, Dallas 11, Texas *10A-1*
O'Clare, Albert R., 3301 P Street, N.W., Washington, District of Columbia *14M-4*
O'Connell, Daniel E., 2753 Ohio Avenue, Redwood City, California *37A-1*
O'Connell, Daniel G., 425 Atwood Street, Pittsburgh 13, Pennsylvania *3A-1*
O'Connell, John, Messrs. Lake/Elliot Limited, Chapel Hill, Braintree, Essex, England *0A-1*
O'Connell, Joseph P., 24006 Huber Avenue, Lomita, California *23A-1*
O'Connell, Timothy W., 5416 Yermo, Toledo 13, Ohio *36AF-4*
O'Connor, Charles W., 36 Woodland Road, Wakefield, Massachusetts *30A-2*
O'Connor, Donald T., R.R. 4, Crawfordsville, Indiana *35A-2*
O'Connor, John E., Plant Industrial Engineer, International Harvester Company, 1360 Fifty-ninth, Emeryville, California *12M-4*
O'Connor, Joseph M., 520 East Grant Street, Olyphant, Pennsylvania *77AF-4*
O'Connor, Richard W., 90 Maple Hill Road, Huntington, New York *86M-4*
O'Connor, Robert B., 4S201 Evergreen Drive, Lisle, Illinois *25A-3*
O'Connor, Roderick A., Jr., 112 North Third Street, Geneva, Illinois *25A-1*
O'Connor, Thomas F., 2830 Morgan Avenue, Oakland 2, California *12M-4*
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Odom, Ralph G., 8618 West Eleventh Avenue, Phoenix, Arizona *70A-2*
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Ogden, Robert S., 154 Le Gran Road, Rochester 17, New York *44M-4*
Ogle, Kenneth A., 5438 Chippewa, St. Louis 9, Missouri *16A-2*
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O'Keeffe, William H., 5853 Rhode Island Avenue, Cincinnati 37, Ohio *8A-2*
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Okin, Mrs. Jack, 160 Prospect Street, East Orange, New Jersey *61A-2*
Okrepkie, Ralph G., 105 Haverhill Street, Lawrence, Massachusetts *62A-2*
Oldham, Marvin Earl, Caterpillar Tractor Company, 800 Davis Street, San Leandro, California *12M-4*
Olejnik, Stanley N., Western Electric Company, Incorporated, Box 1400, Peony Park Station, Omaha 14, Nebraska *90M-4*
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Olijnek, Nicholas, 3240 Drew Avenue, N., Minneapolis 22, Minnesota *38M-4*
Olinger, George F., 3744 Salem Avenue, Dayton 6, Ohio *2M-4*
Oliver, Duward H., 67 North Holmes, Memphis 11, Tennessee *28A-2*
Oliver, Jack D., c/o Martin Company, M. B. 83, Orlando, Florida *27A-2*
Oliver, Roy C., Jr., Box 572, Hawkins, Texas *60A-2*
Oliver, William E., Eli Lilly and Company, 740 South Alabama, Indianapolis 6, Indiana *65M-4*
Oliver, William H., American-Standard, Bond Plant, 25 Rano Street, Buffalo 7, New York *49M-3*
Olivet, Louis V., Jr., 15 White Street, Lunenburg, Massachusetts *30A-2*
Oller, Hugh H., 4301 Diane Drive, Mobile, Alabama *79AF-4*
Ollila, Raymond J., 5706 Verna Way, Concord, California *12M-4*
Olm, Kenneth W., 6100 Nasco Drive, Austin 5, Texas *39A-2*
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Olsen, Don J., Manager of Product Containers, Lehn and Fink Products Corporation, 192 Bloomfield Avenue, Bloomfield, New Jersey *61A-2*
Olsen, Frank P., 13 Clems Drive, Essex Junction, Vermont *0A-1*
Olsen, William R., 2094 Delmont Drive, Salt Lake City, Utah *50M-4*
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Olson, Frederick G., 1721 Eleventh Avenue, Moline, Illinois *46M-4*

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O'Neill, William T., 222 Hamilton, Glen Rock, New Jersey *61A-4*

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Ono, Tsuneo, Nippon Management Association, Sanko-Building, 2-5 chome Ginza-Nishi, Chuo-Ku, Tokyo, Japan *0M-3*

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Orr, Sydney C., Jr., 2473 Ash Drive, Springfield, Ohio *0M-3*

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Ortendahl, Raymond B., 1614 Norwood Avenue, Prospect Park, Pennsylvania *31M-4*

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Owens, Jimmie M., Mead Corporation, Kingsport, Tennessee *17A-1*

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Ozanne, Warren, 4736 Homer, Dallas, Texas *10A-1*

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Pace, Eldon, 282 North Lakeview, Clearfield, Utah *50A-2*

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Page, Clayton E., 51 Clifton Park, Melrose 76, Massachusetts *30A-2*

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Page, Robert H., Johns-Manville Products Corporation, Zelienople, Pennsylvania *3A-1*

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Palken, George, 153 Hackensack Road, Chestnut Hill 67, Massachusetts *30M-4*

Pall, Raymond M., 114 Rosemont Drive, San Antonio 1, Texas *39M-4*
Palmer, Alten C., 223 North Prospect Street, Herkimer, New York *85A-4*
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Palmer, Frank P., 269 Washington Street, Woburn, Massachusetts *30AF-4*
Palmer, Robert J., 15763 One Hundred Nineteenth Place, S.E., Renton, Washington *20A-2*
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Palmer, William L., 826 Bennington Avenue, N.E., Massillon, Ohio *19M-3*
Palmieri, Louis B., 141 Eastern Way, Rutherford, New Jersey *61AF-4*
Panara, Ned E., Hewitt-Robins, Incorporated, 240 Kensington Avenue, Buffalo 5, New York *49A-1*
Pantalone, John R., 18 Young Avenue, Croton-on-Hudson, New York *5A-2*
Panter, Arthur M., 2884 Northwest Raleigh, Portland 10, Oregon *67A-1*
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Pappas, Aristotle T., 3058 Roe, Houston, Texas *22A-1*
Pappas, Harry, Jr., 8842 Ventura Street, Anaheim, California *23M-4*
Paradice, William L., Jr., 1399 Westmont Road, S.W., Atlanta 11, Georgia *6M-4*
Paramore, Rulon C., 688 Montgomery Drive, Sandy, Utah *50AF-4*
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Parden, Robert J., College of Engineering, University of Santa Clara, Santa Clara, California *37M-4*
Parise, Sylvester M., Standard Cost Department, Weirton Steel Company, Weirton, West Virginia *0A-1*
Paris, Floyd J., International Business Machines Corporation, Department 374, Endicott, New York *96A-1*
Parish, Robert E., 105 Fairview Avenue, Painted Post, New York *48M-3*
Park, F. W., 24 Hookhollow Road, Novelty, Ohio *7M-4*
Park, Frank A., 1551 Thirty-fourth Avenue, Moline, Illinois *46M-4*
Park, Robert L., Houghton Mifflin Company, Riverside Press, 840 Memorial Drive, Cambridge 38, Massachusetts *30M-4*
Parker, Arthur L., 6486th Camron, APO 953, San Francisco, California *0A-1*
Parker, Clarence C., 7015 Whitesburg Drive, S.E., Huntsville, Alabama *69M-4*
Parker, Dwight L., 4002 East Elm, Wichita, Kansas *56A-2*
Parker, Harry William, 433 Fair Street, Berea, Ohio *7M-4*
Parker, James B., Jr., Box 321, Mount Olive, North Carolina *66AF-3*
Parker, John F., 443 East Ninth Street, National City, California *29M-3*
Parker, Kenneth L., 5248 Madison, Sacramento, California *43A-2*
Parker, Robert M., 35 Forest Avenue, Riverside, Illinois *25A-1*
Parker, Ronald, Box 9876, Fort Worth 7, Texas *10A-1*
Parker, Russell H., 6624 Ash Avenue, Gary, Indiana *53A-1*
Parker, Sumner, 1331 Goodbar Avenue, Memphis 4, Tennessee *28A-2*
Parker, Verdun L., 2441 Princeton Drive, San Bruno, California *37M-4*
Parker, W. Dale, 208 Third Avenue, Lyndalia, Wilmington, Delaware *100A-1*
Parker, Wendell R., 88 Cleopatra Drive, Concord, California *12M-4*
Parker, William E., 7103 Meadowbrook Road, Lynchburg, Virginia *101M-4*
Parkhouse, Leonard F., Canadian Westinghouse Company, Limited, Sanford Avenue, N., Hamilton, Ontario, Canada *87M-3*
Parkinson, Morville A., Canadian General Electric, 214 King Street West, Toronto, Ontario, Canada *87M-3*
Parkman, Richard J., R.R. 9, Box 177A, Fort Worth, Texas *10A-1*
Parks, David H., 2101 Twenty-first Avenue, S., Birmingham 9, Alabama *9A-2*
Parks, Edwin R., 3355 Mildred Lane, Lafayette, California *12M-4*
Parks, George M., 2480 Virginia Street, Berkeley 9, California *12A-2*
Parks, John H., 4040 Hilliard-Cemetery Road, Hilliards, Ohio *1M-4*
Parks, Kay D., 5117 West Moor Road, Salt Lake City 17, Utah *50A-2*
Parks, Newton I., 6 Lexington Road, Bordentown, New Jersey *31A-4*
Parks, Robert S., 350 Derwyn Road, Lansdowne, Pennsylvania *31A-2*
Parks, William R., 320 La Herran Drive, Santa Clara, California *37A-1*
Parrish, Bobby M., R.R. 1, Box 204, Metter, Georgia *0A-1*
Parrish, Karl M., 722 Carolina Avenue, Gastonia, North Carolina *83A-2*
Parrott, Cecil W., 16245 Southeast Seventh, Bellevue, Washington *20A-2*
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Parson, Edwin R., 218 Christian, Hubbard, Ohio *24A-3*
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Parsons, Stephen J., 460 Hancock Street, West Abington, Massachusetts *30A-2*
Parsons, Norman, 226 The Kingsway, North, Islington, Ontario, Canada *87M-3*
Partridge, Lawrence R., c/o Khuzestan Development Service, P.O. Box 14, Ahwaz, Khuzestan, Iran *0M-3*
Parvin, Robert, 2597 Alma, Palo Alto, California *37A-1*
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Pascuzzi, Joseph L., 2006 Cullum Drive, Reading, Pennsylvania *0A-1*
Pashalian, John L., 65 West One Hundred Eighty-first Street, New York 53, New York *5M-4*
Pasquale, Carl John, 49 Baltusrol Way, Short Hills, New Jersey *61M-4*
Passante, Edward C., 8410 Northwest Twenty-third Avenue, Miami, Florida *40A-1*
Passey, Robert K., 167 "I" Street, Salt Lake City 3, Utah *50A-2*
Passmore, Lyle F., American Forging and Socket Company, 150 Branch Street, Pontiac, Michigan *47A-2*
Pate, John William, 712 Scenic Drive, Morristown, Tennessee *11M-4*
Patel, V. M., Vithal Chawk, P. O. Dharmaj, (Dist Kaira), Bombay State, India *0A-1*
Paterson, Duncan W., 127 Simpson Street, Sault Ste. Marie, Ontario, Canada *0A-1*
Paterson, John, 250 Oakwood Avenue, Apartment 9, Toronto 10, Ontario, Canada *87M-3*
Patrick, Austin E., 28093 Wildwood Trail, Farmington, Michigan *47M-4*
Patronik, John M., 17210 South Throop Street, Hazel Crest, Illinois *25A-1*
Patten, Ezra B., 1215 South 050 West, Orem, Utah *50A-2*
Patterson, Burton B., 1401 Forty-third Street, Birmingham 8, Alabama *9M-4*
Patterson, David C., 400 Nineteenth Street, Moline, Illinois *46A-2*
Patterson, David G., 586 Lakewood Road, Walnut Creek, California *12M-4*
Patterson, David G., 13 Norris Street, Wellsboro, Pennsylvania *48A-1*
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Pearce, William B., 1200 West Cleermont Circle, S.E., Huntsville, Alabama *69M-4*
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Peck, Kenneth W., The Chemstrand Corporation, P.O. Box 1507, Pensacola, Florida *33A-1*
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Peckham, Herbert H., 57 The Strand, New Castle, Delaware *100A-1*
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Perdue, Paul P., 4867 North Newhall Street, Milwaukee 17, Wisconsin *45M-4*
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Perez-Guerrero, Fernando, Apartado Postal 30239, Mexico 7, D.F., Mexico *0M-3*
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Peters, Charles H., Raybestos-Manhattan, Incorporated, Steigel Street, Manheim, Pennsylvania *71M-4*
Peters, Frank W., 7 Somerset Lane, Mill Valley, California *12A-4*
Peters, Raymond H., 882 West Spruce Street, Ravenna, Ohio *7M-4*
Peters, Richard J., 1768 Academy Place, Dayton 6, Ohio *2A-2*
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Petersen, Hans G., 710 Monroe Street, Endicott, New York *96A-3*
Petersen, Melvin J., 2560 Ranburn Drive, Gary, Indiana *53M-3*
Petersen, Raymond F., Route 4, Crawfordsville, Indiana *35A-2*
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Peterson, Edward L., 2830 Adams, N.E., Albuquerque, New Mexico *59A-1*
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Peterson, Lawrence C., 5704 North Merrimac Avenue, Peoria, Illinois *80A-2*
Peterson, LeRoy W., 2343 Twenty-four One Half Street, Rock Island, Illinois *46A-2*
Peterson, Ralph A., 3826 Kirkwood Road, Philadelphia 14, Pennsylvania *31A-2*
Peterson, Raymond E., Sr., 1253 Gleneagle Road, Baltimore 12, Maryland *42A-2*
Peterson, Robert C., 2100 Esteben, Arabi, Louisiana *74A-2*
Pethick, David W., Federal-Mogul-Bower Bearings, Incorporated, Bower Roller Bearing Division, 3040 Hart Avenue, Detroit 14, Michigan *47A-2*
Petlin, Jack W., 1843 South Filbert Court, Denver 22, Colorado *32A-3*
Petrie, Leslie D., 3 Warren Street, Grafton, Massachusetts *68A-2*
Petro, John S., 13995 Superior Road, Apartment 302, East Cleveland 18, Ohio *7M-1*
Petroff, Peter, 2319 Gary Avenue, Granite City, Illinois *16A-2*
Pettegrew, Robert L., Management Analyst, The Port of New York Authority, 111 Eighth Avenue, New York 11, New York *5AF-1*
Pettersen, Ole A., 468 Stow Avenue, Oakland 6, California *12AF-3*
Petterson, Karl E. E., 201 South One Hundred Eighty-sixth, Seattle 88, Washington *20M-1*
Petticrew, William K., Jr., 209 North Byers Avenue, Joplin, Missouri *0A-1*
Pettit, Smith D., 6769 Neptune Place, Apartment 12, La Jolla, California *29A-1*
Petty, Wayne E., P.O. Box 187, Corning, California *12M-1*
Pettyjohn, James F., 423 Johnson, Little Rock, Arkansas *84A-1*
Pettyjohn, Janis Jean, Apartment 210, 1525 La Salle, Minneapolis 3, Minnesota *38A-2*
Petz, Richard A., 1804 Telegraph Road, Alexandria, Virginia *14AF-1*
Pezzotti, Charles P., 78 Fairview Avenue, Piedmont 10, California *12M-1*
Pfeiffer, Lewis E., 113-14 Seventy-second Road, Forest Hills 75, New York *5A-2*
Pfender, John F., 595 Westchester Trail, Chesterland, Ohio *7M-1*
Pfister, Harlan Elliott, R. R. Donnelley and Sons Company, 350 East Twenty-second Street, Chicago 16, Illinois *25M-1*
Pflum, Frederick W., RFD 1, Box 99, Rosendale, New York *76A-1*
Pfotzer, William, Apartment 29F, United States Naval Ammunition Depot, Charleston, South Carolina *0A-1*
Phelan, Halpin M., 309 Oread Road, Louisville 7, Kentucky *18M-3*
Phelan, Milton T., 133 Earl Street, Joliet, Illinois *25A-1*
Phelan, Thomas F., Aronimink Arms Apartments, Building 'D' Apartment 1-C, City Line and Childs Avenue, Drexel Hill, Pennsylvania *31A-2*
Phelps, Colbert M., Commonwealth Cedar Company, Shelbyville, Tennessee *73AF-3*
Phelps, George T., 217 Nesbitt, Poland 14, Ohio *24M-3*
Phelps, James C., Drawer 1267, Ponca City, Oklahoma *0M-3*
Phelps, John W., 1311 North Raymond, Fullerton, California *23A-1*
Philbrooks, Bryce, 2833 Patricia, Antioch, California *12A-2*
Philips, Robert W., Kaiser Aluminum and Chemical Corporation, P.O. Box 566, Erie, Pennsylvania *51M-1*
Phillips, Charles E., Jr., 125 Plantation Road, Route 4, Smyrna, Georgia *6M-1*
Phillips, Clair A., General Tire and Rubber, 1708 Englewood Avenue, Akron 9, Ohio *52M-1*
Phillips, Dean N., 3126 F. Road, Clifton, Colorado *0A-1*
Phillips, Donald D., 9247 Wooden Bridge Road, Philadelphia 14, Pennsylvania *31AF-1*
Phillips, Herman A., 1336 Thompson, Evansville, Indiana *88A-2*
Phillips, Joe F., 622 Penguin Drive, Dallas 32, Texas *10A-3*
Phillips, Lewis A., Ethyl Corporation, Baton Rouge, Louisiana *41A-1*
Phillips, Richard C., Box 360, Muncy, Pennsylvania *89M-3*
Phillips, Richard F., General Telephone Company, P.O. Box 1001, San Angelo, Texas *0A-1*
Phillips, Robert V., 481 Sycamore, Claremont, California *23A-1*
Phillips, William C., Project Management Department, Utah Division, Thiokol Chemical Company, Brigham City, Utah *50M-4*
Phillips, William J., 5 Linden Street, Binghamton, New York *96A-1*
Phillips, William Raymond, Moore Business Forms, Incorporated, 800 South Raymond Avenue, Fullerton, California *23AF-3*
Phillips, William T., 304 Ninth Street, Radford, Virginia *81A-1*
Philpott, Harry W., 801 Kenwick Road, Winston-Salem, North Carolina *21A-4*
Phoenix, Paul J., Dominion Foundries and Steel Limited, Depewst, Hamilton, Ontario, Canada *87A-1*
Pianin, Albert, 133 Loomis Drive, West Hartford 7, Connecticut *75A-4*
Piantoni, Leo E., 230 East Locust, Brea, California *23AF-3*
Picciotti, Velio G., 5410 Mary Lane Drive, San Diego 15, California *29A-3*
Pickard, Donald E., 505 Southwest First, Bethany, Oklahoma *57A-2*
Pickens, Robert R., 112 Ornida Avenue, M.R. 9, Beaver, Pennsylvania *0A-1*
Pickup, Roy, 9 Prince Street, Heywood, Lancashire, England *30A-2*
Pier, Herbert, 9222 Liptonshire Drive, Dallas 31, Texas *10A-1*
Pierce, Barry W., 3724 Mactibby Street, San Diego 17, California *29A-1*
Pierce, Edward A., 15 Hill Street, Somerville, Massachusetts *30A-2*
Pierce, Harry J., 7708 Beaverland Avenue, Detroit 39, Michigan *47A-2*
Pierce, Jay L., Route 2, Box 185, Theodore, Alabama *79A-2*
Pieri, Louis, Buxton, Incorporated, 365 Main Street, Agawam, Massachusetts *94M-4*
Pierson, Edward G., Jr., 4556 Indian Ridge Road, Sylvania, Ohio *36A-2*
Pierson, Roy A., 860 South Raritan, Denver 23, Colorado *32A-1*
Pieta, Edward T., International Nickel Company, Incorporated, Guyan River Road, Huntington 17, West Virginia *58M-4*
Pigage, Leo C., University of Illinois, Urbana, Illinois *80M-4*
Pike, August A., 1437 Bretton Street, Winston-Salem, North Carolina *21A-2*
Pike, Leroy H., 7 Gardner, Newburgh, New York *76A-2*
Pike, Richard O., 1433 Southeast Third Street, Pampano Beach, Florida *0A-1*
Pikey, Ray A., Carter Carburetor, Division ACF Industries, 2840 North Spring Avenue, St. Louis 7, Missouri *16A-2*
Pillar, John P., 1020 Pine S.E., Republic Steel, Warren, Ohio *24M-3*
Pinegar, James J., Columbia-Geneva Steel Corporation, USC, P.O. Box 510, Provo, Utah *50A-2*
Pines, David L., 29 West Thirty-fifth Street, Bayonne, New Jersey *61A-2*
Piness, George, Jr., Wayne Manufacturing Company, 1201 East Lexington, Pomona, California *78A-2*
Pinkovitz, Jacob, 56 Cottage Street, Chelsea 50, Massachusetts *30A-2*
Pinochet, James, 1414 Bose Avenue, Rock Hills, South Carolina *0A-1*
Pinto, Michael, Pioneer Engineering and Manufacturing Company, 19669 John Road, Detroit 3, Michigan *47M-4*
Pinyan, Billy A., P.O. Box 892, Black Mountain, North Carolina *83AF-4*
Pipp, Harold P., 1404 Carlisle Road, Camphill, Pennsylvania *95A-2*
Pirich, John N., Box 254, Clemson, South Carolina *0M-3*
Pirkle, Donald S., 834 East Division Street, Dover, Delaware *0A-1*
Pirtle, J. W., Apartment 6, Henryetta Apartments, 504 West Second, Borger, Texas *0A-3*
Pistole, Robert G., 1416 McKennie, Nashville, Tennessee *64A-1*

Pisula, Arthur B., 1712 Heathlon Street, Pittsburgh, Pennsylvania *3A-1*
Pitcher, Benjamin A., 373 Tamarac Trail, Kettering 29, Ohio *2A-2*
Pitman, Robert W., 4200 Japonica Lane, Charleston 2, West Virginia *58M-4*
Pitts, D. Milton, 1310 Powers Ferry Road, Marietta, Georgia *6M-4*
Placke, Harry E., 234 Hillcrest Drive, Sidney, Ohio *0A-3*
Plaggemier, Henry F., 1970 East Two Hundred Twenty-first Street, Euclid 17, Ohio *7M-4*
Plane, Lewis A., Mead, Johnson and Company, 2404 West Pennsylvania, Evansville, Indiana *88A-2*
Platten, Jack R., 1514 North Washington Street, Wheaton, Illinois *25M-4*
Playle, George A., 352 Retford Avenue, Cranford, New Jersey *5A-4*
Pleydell, John W., Werner Textile Consultants, c/o De Danske Bomuldsspinderier, Vejle, Denmark, Europe *0A-1*
Plotkin, David S., 6620 Dickens, Dallas 5, Texas *10A-1*
Plourde, Albert M., 107 Dundee Circle, St. Louis 37, Missouri *16A-2*
Plummer, Calvin C., 1419 North Blair, Royal Oak, Michigan *47A-2*
Plummer, Frederick C., 141 Oak Place, Pittsburg, California *12M-4*
Plummer, Henry M., All Angels Road, Wappingers Falls, New York *76A-2*
Plummer, Robert L., c/o Westinghouse Educational Center, Ardmore Boulevard at Brinton Road, Pittsburgh 21, Pennsylvania *3A-1*
Poage, Scott T., P.O. Box 222, Stillwater, Oklahoma *0M-3*
Podell, Harold, R.D. 2, Oneida, New York *85A-2*
Podlaha, Otto C., 510 North Sleight, Naperville, Illinois *25M-4*
Poggi, Andrew D., Methods Analyst, Buxton, Incorporated, 265 Main Street, Agawam, Massachusetts *94A-2*
Pohl, Henry A., Potter and Brumfield, Incorporated, 1200 East Broadway, Princeton, Indiana *88A-2*
Pohl, John G., Jr., 14 Taylor Place, Harrington Park, New Jersey *61AF-4*
Pohle, Charles C., 8411 Eulalie, Brentwood 17, Missouri *16A-4*
Pohlman, George G., 106 Columbus Way, Weirton, West Virginia *0A-1*
Pohmajevich, Francis, 425 Ridgewood Drive, Metairie, Louisiana *74A-2*
Pokrass, William M., 10046 West Fiebrantz Avenue, Milwaukee 16, Wisconsin *45M-4*
Poli, David L., 2515 Frances Street N.E., Albuquerque, New Mexico *59A-1*
Polinsky, Albert S., 730 Clark Street, Ridgefield, New Jersey *5A-2*
Polinski, Joseph J., Bridge Street, Phoenixville, Pennsylvania *31M-4*
Polisco, Joseph W., 703 Fern Dell Drive, Elmira, New York *48A-1*
Polishook, Burton H., 2455 Cruger Avenue, Bronx 67, New York *5A-2*
Politinsky, Seymour I., 9669 South Luella Avenue, Chicago 49, Illinois *25A-1*
Polk, Edward J., 7111 Flushing Road, Flushing, Michigan *47A-2*
Pollak, Benjamin, 75-30 Sixty-seventh Drive, Middle Village 79, New York, New York *5A-4*
Pollack, Sidney J., 6 Brinkerhoff Avenue, Teaneck, New Jersey *61M-4*
Pollard, Gerald M., 521 Indiana, Vallejo, California *12A-2*
Pollard, Robert L., 1221 West Governor, Springfield, Illinois *80M-4*
Pollard, Wayne J., 1907 Lafayette Street, San Gabriel, California *23A-1*
Polli, Joseph A., Jr., 320 West Coal Street, Shenandoah, Pennsylvania *89A-2*
Pollpeter, Elmer J., Route 1, West Point, Iowa *0A-1*
Pool, Fletcher M., 1729 Walnut Street, Grand Prairie, Texas *10A-1*
Poole, Ray V., 1531 Harding Street, Winston-Salem, North Carolina *21A-2*
Poor, Golden E., 631 East Fourth, N., Orem, Utah, *50A-2*
Poore, Daniel M., 120 Washington Road, Pittsburgh 21, Pennsylvania *3A-1*
Poore, George R., 61 Straub Road, Rochester 15, New York *44A-2*
Poorter, Louis E., 609 Scenic Loop, Marshall, Texas *60A-2*
Pope, E. Marion, 1805 Shadowlawn, Jacksonville 5, Florida *27A-4*
Pope, William F., 18813 Chandler Park Drive, Detroit 36, Michigan *47M-4*
Pope, Wilfrid R., Jr., 215 Dunrovin Lane, Rochester 18, New York *44A-4*
Popovich, Ray L., 1286 Minnesota Avenue, Columbus 11, Ohio *1A-2*
Popplewall, Francis J., 206 Raymond, Bay City, Michigan *98M-4*
Porfiri, E. Austin, 325 Northwest Forty-third Avenue, Miami 35, Florida *40AF-3*
Porteous, Robert T., 2630 Phillip Street, Winston-Salem, North Carolina *21A-2*
Porter, David Burr, 113 Cassilis Avenue, Bronxville, New York *5F-0*
Porter, Donald T., 3443 West Myrtle, Phoenix, Arizona *70A-2*
Porter, Howard, Electric Storage Battery Company, Rising Sun and Adams Avenue, Philadelphia 20, Pennsylvania *31M-4*
Porter, Jimmie Roy, 1320 Virginia, Bryan, Texas *0A-1*
Porter, John H., Singe Manufacturing Company, 915 Pembroke, Bridgeport 8, Connecticut *82A-2*
Porter, Marvin G., 4554 South Lamon, Chicago 38, Illinois *25AF-3*
Porter, Robert N., Jr., 1264 Marshall Drive, West Lafayette, Indiana *35A-2*
Porter, Vernon S. C., Colorado Fuel and Iron Corporation, Pueblo, Colorado *32A-1*
Porter, William C., Ontario Hydro, 84 Collier Street, Barrie, Ontario, Canada *87M-3*
Portman, John A., 427 East Grinnell Drive, Burbank, California *23M-4*
Portmess, Robert R., 3067 West 3180 South, Salt Lake City 4, Utah *50A-2*
Posey, John T., 1200 Keith, Wichita 9, Kansas *56A-2*
Posner, Philip, c/o Hobson 1A, 239 East Seventy-seventh, New York 21, New York *5A-2*
Poston, Irvin E., 2496 Devon Lane, Birmingham, Michigan *47A-2*
Posz, Charles L., United States Steel Corporation, Gary Sheet and Tin Mill, Station H, Gary, Indiana *53M-3*
Potratz, John H., 6505 Graylock Lane, North Highlands, California *43A-2*
Potter, Thomas C., 3311 Grandview Avenue, Louisville 7, Kentucky *18M-3*
Potts, Martin Q., 154 Andover Road, Woodsfield, Ohio *0A-1*
Potts, William J., 967 Ordway Street, Albany 6, California *12A-4*
Pound, Herbert E., 5235 Eighty-second Avenue, S.E., Mercer Island, Washington *20AF-3*
Powell, Bruce R., Eyland Avenue, Succasunna, New Jersey *61A-2*
Powell, Fred P., 77 Long Island Place, N.W., Atlanta 5, Georgia *6A-2*
Powell, John T., 3626 West Liberty Street, Cincinnati 5, Ohio *8M-4*
Powell, Walter L., Jr., 14729 Twenty-second Avenue, Seattle 55, Washington *20A-2*
Powell, William M., 4444 Thirty-eighth Street, N., Arlington, Virginia *14A-2*
Power, H. D., 109 Eaker Drive, Warner Robins, Georgia *55A-1*
Power, Richard J., 4088 Eckworth Drive, R.R. 1, Bellbrook, Ohio *2M-4*
Powers, James E., 1706 Summerlane, S.E., Decatur, Alabama *69A-2*
Powers, Joseph H., Forest Trail, Ely Road, Farmington, Connecticut *75M-4*
Powers, Maston Linzie, 1501 South Berry Road, Norman, Oklahoma *57M-4*
Powers, Richard J., The Gamewell Company, Newton Upper Falls, Massachusetts *30M-4*
Poynter, Robert N., 2544 East Highland Avenue, Phoenix, Arizona *70A-2*
Prado, Manuel S. Magno, 4243 Twenty-fifth Street, Detroit 8, Michigan *47A-2*

Prashker, Eugene I., Apartment 6A, Garfield Park Apartments, Metuchen, New Jersey *5A-2*
Prather, Donald E., 6331 Mallo Place, Cleveland 30, Ohio *7A-2*
Prather, Ralph B., 1305 Hele Street, Kailua, Hawaii *0A-1*
Prather, William E., 800 Wilson Avenue, Tullahoma, Tennessee *64M-3*
Pratt, Cleveland F., Jr., 50 Mount Avenue, Freeport, New York *86A-2*
Pratt, James A., Riverside Foundry, Bettendorf, Iowa *46A-2*
Pratt, Maurice D., 3393 Doyle Street, Riverside, California *78A-2*
Pratt, Robert N., 1586 Emerson Avenue, Salt Lake City 5, Utah *50AF-4*
Preble, Galen W., P.O. Box 744, Edgewood, Maryland *42A-2*
Prendergast, Donn J., 3713 S Street, N.W., Washington 25, District of Columbia *14AF-4*
Presgrave, Ralph, York Knitting Mills, Incorporated, Toronto, Ontario, Canada *87F-0*
Press, Bernard C., 427 Pascack Road, Westwood, New Jersey *61A-4*
Press, Irving, 118 Medford Road, Dumont, New Jersey *5A-4*
Pressel, Earl L., 17336 Edinborough, Detroit 19, Michigan *47M-4*
Pressprich, Robert C., 2185 Anderson Road, Saginaw, Michigan *98A-2*
Preussel, Willard G., Western Electric Company, Lexington Road, Winston-Salem, North Carolina *21M-4*
Prewitt, Max R., 528 North Kickapoo, Shawnee, Oklahoma *57A-2*
Pribis, Steven, Jr., 5 Bellewood Circle, North Syracuse 12, New York *13M-4*
Price, Charles A., 1358 Greenwood Avenue, Mobile, Alabama *79M-4*
Price, John R., Turnbuckles, Incorporated, Box 333, Michigan City, Indiana *0A-1*
Price, Lawrence, Specialty Electric and Engineering Company, 79 Clifton Place, Brooklyn 38, New York *5A-2*
Price, Mardis L., 2059B North Woodlawn Drive, Mobile, Alabama *79A-2*
Price, Robert P., R.R. 2, Winslow, Indiana *88AF-4*
Prichard, Gregory, Industrial Engineer, Sperry Utah Engineering Laboratory, 322 North Twenty-first, Salt Lake City 14, Utah *50M-4*
Priebe, Marvin, 330 Blackfield Drive, Concord, California *12AF-3*
Priest, Russell A., National Supply Company, 3320 Bishop Street, Toledo 6, Ohio *36M-4*
Prigmore, James A., Combustion Engineering Incorporated, 911 West Main Street, Chattanooga 1, Tennessee *54A-2*
Primeaux, Roswell J., 511 South Sante Fe, Norman, Oklahoma *57A-2*
Prince, Ralph P., Assistant Professor, Department of Agricultural Engineering, The University of Connecticut, Storrs, Connecticut *75A-2*
Pritchard, Paul J., 22 Frontier Drive, Poland, Ohio *24A-3*
Probala, Robert V., Box 560, Route 3, Golden, Colorado *32A-1*
Prociak, Myron J., 206 Cleveland Avenue, Liverpool, New York *13A-2*
Prosser, Benjamin D., 14515 Union Avenue, Chicago 27, Illinois *25M-4*
Prosser, David C., 1562 Northwest Bank Building, Minneapolis 2, Minnesota *38M-4*
Provost, Robert G., Sr., 730 Benmac Road, Smyrna, Georgia *6A-2*
Prow, Ernest R., 306 Lindwood, Savannah, Georgia *26A-1*
Pruce, Peter P., 134 South Wetherly Drive, Los Angeles 48, California *23M-4*
Prudhomme, Paul P., 1914 Passolt Street, Saginaw, Michigan *98M-4*
Pruett, Dresslar M., 5766 East Thirtieth Street, Tulsa, Oklahoma *15A-1*
Puchalski, Joseph B., 339 Boston Street, Syracuse 6, New York *13A-2*
Puckett, Johnny R., 110 North Church Street, Mt. Olive, North Carolina *66A-1*
Puff, Harold F., School of Business, Miami University, Laws Hall, Oxford, Ohio *8A-2*
Pugliese, Michael J., 58 Ewingville Road, Trenton, New Jersey *31A-2*
Pulliam, Andrew B., 209 Southmoreland Place, Decatur, Illinois *80M-4*
Pullman, Robert A., 329 Hawthorn Street, New Bedford, Massachusetts *30M-4*
Purdom, Clyde H., 544 Schoolway, Louisville 14, Kentucky *18M-3*
Purdy, William S., 532 Stewart, Marietta, Georgia *6A-2*
Purslow, Clifford R., 4930 Lunar Drive, Columbus 14, Ohio *1AF-4*
Pusch, James L., 6055 Brentwood Street, Arvada, Colorado *32M-3*
Putnam, Frank R., 236 Morewood Road, Glenshaw, Pennsylvania *3AF-3*
Putney, Homer L., American Viscose Corporation, Nitro, West Virginia *58A-2*
Pyle, Clarence Joseph, 1121 Parkside Drive, Oak Lane Manor, Wilmington 3, Delaware *100M-3*
Pyle, George E., 12 Crestview Lane, M.R. 1, Milford, Ohio *8M-4*
Pylant, James A., 1545 Gaston Street, Monticello Apartments, A-6, Winston-Salem, North Carolina *21A-2*
Pytel, Edward J., 56 Dolan Street, Sayreville, New Jersey *61A-2*
Pytel, Leonard P., 15 Carmel Avenue, El Cerrito 8, California *12A-4*
Pyzel, Robert J., 2026 Blue, Richland, Washington *0A-1*

Quaney, Robert A., 916 Seena Avenue, Los Altos, California *37A-1*
Querbach, Edward E., 15 Huntington Avenue, Lynbrook, Long Island, New York *5M-4*
Quick, Carl F., 1161 Cuyamaca, Chula Vista, California *29M-3*
Quick, Joseph H., 32 West Main Street, Westboro, Massachusetts *30M-4*
Quick, Robert A., 17 Gilmore Boulevard, N., Wappingers Falls, New York *76M-4*
Quilici, Ray A., 1306 Hale Drive, Concord, California *12A-2*
Quinby, William K., Jr., General American Transporation Corporation, Box 532, Sharon, Pennsylvania *24M-3*
Quinn, Charles T., Birmingham Paper Company, 2110 Fifth Avenue, S., Birmingham 3, Alabama *9A-2*
Quinn, Ed., 15 Vine Court, Centereach, Long Island, New York *86A-2*
Quinn, J. F., Assistant Plant Industrial Engineer, United States Steel Corporation, Clairton Works, State Street, Clairton, Pennsylvania *3M-3*
Quinn, Thomas J., P.O. Box 827, Daingerfield, Texas *60A-2*
Quinn, Wallace, 832 South Fourth Street, Apartment 9, Alhambra, California *23A-1*
Quintana, Jorge, Cerro de Pasco Corporation, La Oroya, Peru, South America *0M-3*

Raab, Ferdinand H., Copperweld Steel Company, Glassport, Pennsylvania *3M-3*
Race, Dick M., 5585 Raceview, Cincinnati 11, Ohio *8A-2*
Racedo, Ivan L., Juncal 1441 3er piso, Buenos Aires, Argentina *12AF-3*
Rack, Charles W., Oakite Products, Incorporated, 350 Hudson Street, New York 14, New York *61A-4*
Radell, Nicholas J., Program Manager, Touche, Niven, Bailey and Smart, 1292 National Bank Building, Detroit 26, Michigan *47M-4*
Radford, Charles J., 263 Datura Street, Pensacola, Florida *33A-1*
Radford, Jack F., c/o Florence Stove Company, 2207 West Station Street, Kankakee, Illinois *0M-3*
Radin, William, 142-25 Pershing Crescent, Briarwood 35, New York *5A-2*
Radomski, Joseph E., Jr., Kimberly-Clark Corporation, Kimberly, Wisconsin *45A-4*
Raff, Dwight E., Ocean SYSLANT CINCLANTFLT Headquarters, United States Naval Base, Norfolk, Virginia *99A-2*
Raffaelli, A. Robert, 528 F Walker Avenue, Baltimore 12, Maryland *42A-2*
Raghunath, 8953, Naya Mohalla, Pul Bangash, Delhi 6, India *4A-S*
Rahning, Fred, 946 Havana Street, Aurora, Colorado *32A-1*
Railey, John E., 2749 Northwest Twentieth Street, Oklahoma City 7, Oklahoma *57A-2*
Raimondo, Peter, 714 Sixty-first Street, Brooklyn 20, New York *5A-2*

Rainwater, Leo M., 114 East Crestline Drive, San Antonio 1, Texas *39A-2*
Rakestraw, Olan S., Jr., Gaylord Container Corporation, Container Division, P.O. Box 1034, Atlanta, Georgia *6AF-4*
Rakley, Ira H., 993 Burton, Cincinnati 29, Ohio *8M-4*
Ralston, Robert H., 1610 Locklaine, Pasadena, Texas *22M-4*
Raman, R., Industrial Engineering Department, TISCO, Jamshedpur 1, India *4A-8*
Ramber, Marvin P., Florida Power and Light Company, P.O. Box 3100, Miami 30, Florida *40A-1*
Rambow, Herbert C., 610 Hillside Drive, Hinsdale, Illinois *25AF-3*
Ramlow, William M., Engineering Advisor to Union of Burma, UNTAO, Office for Asia and Far East, United Nations, New York *5M-4*
Ramsay, M. R., Ibcon Private Limited, P.O. Box 1048, Colombo 1, Ceylon *0M-3*
Ramsey, Andrew C., 131 Brookwood Drive, Marietta, Georgia *6A-4*
Ramsey, Jerry D., 1016 Milner Street, College Station, Texas *0A-1*
Ramsey, Rex, 2042 Eastview Avenue, Louisville 1, Kentucky *18M-3*
Ranaldo, Louis C., 16 Ruby Lane, Huntington Station, New York *86M-4*
Ranan, Benjamin Z., 11 Hemlock Drive, Stamford, Connecticut *5M-4*
Rand, Richard S., 14 Merrit Avenue, Kingston, New York *76A-2*
Randall, Daniel E., Lambert-Hudnut Manufacturing Laboratory, 400 West Lincoln Avenue, Lititz, Pennsylvania *71A-2*
Randol, Robert A., 3314 East Thirty-eighth, Indianapolis 5, Indiana *65A-2*
Randolph, Gilbert E., 2026 Ninth Avenue, S., Birmingham 5, Alabama *9A-2*
Randolph, James H., 8807 Cimarron, Los Angeles 47, California *23M-4*
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Raney, Clifton E., 630 East "L," Benicia, California *12AF-3*
Raney, James E., Production Engineer, Department 142, Western Electric Company, 1600 Osgood Street, North Andover, Massachusetts *62A-2*
Raney, Lee C., College of Engineering, University of Missouri, Columbia, Missouri *92A-2*
Ransom, Nealand L., Industrial Engineering Department, Braden Copper Company, Sewell, Chile, South America *0A-3*
Rapp, Rudyard K., 3111 Holly Street, Alexandria, Virginia *14A-2*
Rappoport, Seymour F., 405 Cedar Lane, Teaneck, New Jersey *5M-4*
Rasey, Robert E., 1016 Southwest Seventh Avenue, Gainesville, Florida *27A-2*
Raskin, Seymour H., 602 Terrace Hilton Building, Cincinnati 2, Ohio *8M-4*
Rasmussen, Ronald M., 3710 Tech Boulevard, Winston-Salem, North Carolina *21A-2*
Rasp, Herbert P., 2334 Altadena, San Diego 5, California *29M-3*
Rasul, Robert S., 333 Tioga Street, Johnstown, Pennsylvania *3A-1*
Rathe, Alex W., 165 Westchester Avenue, Thornwood, New York *5M-4*
Rathgeber, William H., Industrial Engineer, Towle Manufacturing Company, 260 Merrimac Street, Newburyport, Massachusetts *62M-4*
Rattner, Joel M., 1226 North Flores Street, Hollywood 46, California *23A-1*
Rauch, Harry A., Jr., 4710 Bell, Apartment 1, Houston 23, Texas *22A-3*
Raven, Julius Stanley, 1182 La Salle Road, Monroe Heights, Pitcairn, Pennsylvania *3M-3*
Raven, Roland R., 405 Carswell Terrace, Arlington, Texas *10A-1*
Ravizza, Kenneth Joseph, 1809 Lexington, Santa Clara, California *37AF-3*
Rawlins, Samuel M., Jr., c/o Continental Can Company, Boston Street and Linwood Avenue, Baltimore 24, Maryland *42A-2*
Rawls, Fitzhugh L., Chemstrand Corporation, Decatur, Alabama *69A-2*
Ray, Charles L., 4023 Crary Drive, Toledo 13, Ohio *36A-4*
Ray, Gerald B., 1723 North Athenian, Wichita, 12, Kansas *56A-2*
Ray, James S., 3501A Ardale Place, Greensboro, North Carolina *21A-2*
Rayburn, Isaac Q., International Petroleum Company, Limited, 396 Alhambra Circle, Coral Gables, Florida *40A-1*
Rayl, Allen B., 508 Holly Lane, Kokomo, Indiana *35A-2*
Raymond, Murray, R., Jr., 12657 Northeast Seventh, Bellevue, Washington *20A-2*
Read, Austin M., 5313 Clairidge Road, Knoxville 18, Tennessee *11A-4*
Reagan, Creed H., 1554 Bacon Park Drive, Savannah, Georgia *26M-3*
Reagan, Edward A., 433 Van Roen Road, Utica, New York *85M-4*
Reagan, Paul W., 6567 Ascot Lane, Dallas 14, Texas *10A-1*
Reardon, Daniel J., 6369 Lewis Avenue, Long Beach 5, California *23A-1*
Reardon, Douglas W., Sears Roebuck and Company, 925 South Homan Avenue, Chicago, Illinois *25M-4*
Reark, Robert T., 3630 Bickerstaff Street, Lafayette, California *12A-2*
Reasman, James C., 1318 North Vine Avenue, Ontario, California *78M-4*
Reban, John D., 322 Mill Road, Oreland, Pennsylvania *31M-4*
Rebhan, John C., 1446 Drexel Avenue, N.W., Warren, Ohio *24M-3*
Rechnitz, Max H., 2475 Field Street, Denver 15, Colorado *32A-1*
Reckler, Arthur, 2333 Cincinnati Avenue, Apartment 2, San Antonio, Texas *39A-2*
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Reddy, John F., Supervisor-Planning, General Electric Company, 166 Broad Street, Fitchburg, Massachusetts *68A-2*
Redman, George P., University of California, Division of Industrial Engineering, Berkeley 4, California *12A-2*
Redmond, Donald G., 124 Donald Avenue, Middletown, Pennsylvania *95M-4*
Reed, Burton K., 22416 Schafer, Mt. Clemens, Michigan *47A-2*
Reed, Charles M., 4840 Baptist Road, Pittsburgh 27, Pennsylvania *3M-3*
Reed, E. Malcolm, 3606 Grand Avenue, Middletown 24, Ohio *8M-4*
Reed, Edward W., Jr., 6709 Dartmoor Way, San Jose, California *37M-4*
Reed, Elmer N., 619 Fairway Drive, Washington Court House, Ohio *0A-1*
Reed, F. William, Jr., 3325 Flora Court, Youngstown 11, Ohio *24A-1*
Reed, George, Jr., 4215 Winchester Road, Louisville 7, Kentucky *18A-1*
Reed, Kersey H., 1320 Donnell, Wichita 16, Kansas *56A-2*
Reed, Lee R., 5839 Pershing Boulevard, Houston 33, Texas *22A-1*
Reed, Raymond, E., 6 East Nelson Avenue, #309-A, Alexandria, Virginia *14A-2*
Reed, Ruddell, Jr., P.O. Box 2388, University Station, Gainesville, Florida *27M-4*
Reed, Stephen A., Jr., C. Brewer and Company, 33 Waianuenue Avenue, Hilo, Hawaii *0M-3*
Reed, S. Kyle, David Lane, Farragut Hills, Concord, Tennessee *11A-4*
Reed, Stuart M., 3304 Nugent Boulevard, Columbus, Indiana *0M-3*
Reeder, Richard E., R.D. 3, Coatesville, Pennsylvania *31A-2*
Reem, Herbert F., 1938 Columbia Pike, Arlington 4, Virginia *14M-4*
Reese, Almer W., Jr., 2055 Ashmore Drive, Dayton 20, Ohio *2AF-4*
Reese, Charles, 120 St. John Drive, Dunlinden Acres, Wilmington 8, Delaware *31A-2*
Reese, Donald E., 138 Oney Avenue, Huntington, West Virginia *58A-2*
Reese, Edward G., 649 East Main Street, Lititz, Pennsylvania *71M-4*
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Reeves, John H., 3035 Wallace Circle, Huntington, West Virginia *58M-4*
Reeves, Robert P., 602 West Jessamine Street, Fitzgerald, Georgia *0A-1*
Reevy, John H., 5938 Mahood Drive, Huntington 5, West Virginia *58M-4*
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Reiber, Richard D., 2310 Seneca Drive, York, Pennsylvania *72A-2*
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Reichenbach, John H., 2131 Dawnlight, Columbus 11, Ohio *1A-2*
Reichert, William F., 302 Placid Drive, San Antonio 1, Texas *39A-4*
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Reid, John W., 14244 Puritas Avenue, Cleveland 35, Ohio *7M-4*
Reidy, Nicholas D., 3843 West Eighty-fourth Street, Chicago 29, Illinois *25A-1*
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Reinert, Louis R., U. A. Lines, Operating Base, Stapleton Air Field, Denver 7, Colorado *32A-1*
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Reinhart, Leroy B., Whirlpool Corporation, 225 West Morgan Avenue, Evansville, Indiana *88A-2*
Reinheimer, Warren E., 116 Andrews Road, Dewitt 14, New York *13M-4*
Reinhold, Fred, Jr., Ronson Corporation of Pennsylvania, Delaware Water Gap, Pennsylvania *77M-4*
Reinsmith, James M., Shenango China, Incorporated, P.O. Box 120, New Castle, Pennsylvania *24M-3*
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Reip, Robert W., R.R. 2, Wappingers Falls, New York *76A-2*
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Reiss, Martin L., 1226 North Flores Street, Hollywood 46, California *23A-1*
Reiter, Bernard, 1410 Forty-eighth Street, N.W., Canton, Ohio *19A-1*
Reitz, Robert E., 1709 Falls Court, Anderson, Indiana *0A-1*
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Reller, Walter L., 617 Bethlehem Pike, Ambler, Pennsylvania *31A-2*
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Rench, John J., 6417 North Tuxedo, Indianapolis 20, Indiana *65M-4*
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Reynolds, Howard W., Box 425, Uxbridge, Ontario, Canada *87A-1*
Reynolds, Louis D., 702 Endicott Avenue, Riverton, New Jersey *31M-4*
Reynholds, Walter H., 452 Echo Road, Vestal, New York *96A-1*
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Rhodes, Hoover, Assistant Chief Industrial Engineer, Watsontown Cab. Division of Philco, Liberty, Watsontown, Pennsylvania *89M-3*
Rhodes, Millard D., Jr., 3362 Medina, Fort Worth 15, Texas *10M-3*
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Rice, Leslie B., 138 Moss Street, Chula Vista, California *29A-1*
Rice, Marvin G., 8201 East Virginia Avenue, Scottsdale, Arizona *70A-2*
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Richards, A. E., Jr., 84 Milwaukee Avenue, Bethel, Connecticut *82A-2*
Richards, Charles H., 915 Eighth Street, Charles City, Iowa *0A-1*
Richards, Fred F., Jr., 577 Highland Avenue, Boston 48, Massachusetts *30A-2*
Richards, Howard G., 9200 Southwest Seventy-first Avenue, Miami 56, Florida *40A-1*
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Richards, William S., 1374 Azalea Drive, Jacksonville 5, Florida *27AF-4*

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Richardson, Robert E., 10330 Outlook, Overland Park, Kansas *92AF-4*

Richardson, Wallace J., Lehigh University, Bethlehem, Pennsylvania *77M-4*

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Richter, Ralph W., 80 Foster Street, Whitesboro, New York *85A-2*

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Rinard, John W., 218 Beverly Drive, San Antonio 1, Texas *39A-2*

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Ring, Howard D., 68 Sterling Street, Brooklyn 25, New York *5A-2*

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Rintala, R. B., 1788 Walnut Street, San Carlos, California *37A-1*

Riordan, Thomas S., 37 Cambridge Road, Whitesboro, New York *85A-2*

Ripple, James H., Mills Industrial Engineering Department, Kennecott Copper Corporation, Arthur Plant, Magna, Utah *50A-2*

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Risimini, Ralph A., 1780 Yorktown Road, Cincinnati 37, Ohio *8M-4*

Rissi, William T., 500 Hillside Drive, Collinsville, Illinois *16A-2*

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Ritter, Theodore E., 9081 Stephanie Lane, Centerville 59, Ohio *2A-2*

Ritter Thomas L., 130 Spinning Road, Dayton 31, Ohio *2A-2*

Ritzel, Arthur R., 5446 Finkman, St. Louis 9, Missouri *16A-2*

Rivel, Avron B., 61 Laventhal Avenue, Irvington, New Jersey *61A-2*

Riveland, Harold R., 7009 Skyline Drive, Dayton 32, Ohio *2M-4*

Rivero, Renaldo, 10 Fernald Street, Concord, New Hampshire *30A-2*

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Roach, James E., Jr., 2708 Ashford Road, N.E., Atlanta 19, Georgia *6A-2*

Roach, Kelsie O., 1838 Huge Oaks, Houston 24, Texas *22A-1*

Roark, Charles L., 391 Glenullen Drive, Pasadena, California *23A-1*

Roark, Donald E., 8671 South Chicago Road, South Milwaukee, Wisconsin *45AF-4*

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Roberts, Calvin N., 3½ Wendell Street, Cambridge, Massachusetts *30A-2*
Roberts, C. Kenard, Plax Corporation, P.O. Box 1019, Hartford, Connecticut *75A-2*
Roberts, Clyde L., Jr., 2166 Brannen Road, S.E., Atlanta 16, Georgia *6A-2*
Roberts, Donald A., 2601 La Vista Road, Decatur, Georgia *6A-2*
Roberts, Donald L., 2908 Troy Avenue, Maryland, Tennessee *11A-1*
Roberts, Edward A., Jr., 410 Riverside Drive, New York 25, New York *5M-1*
Roberts, Harold E., 14221 Chelsea, Detroit 13, Michigan *47A-2*
Roberts, John F., 4066 Kenny Road, Columbus 14, Ohio *1M-1*
Roberts, John S., Hamill Road, R.R. 3, Hixson, Tennessee *54A-2*
Roberts, Leonard B., 10878 Marne, Detroit 24, Michigan *47A-2*
Roberts, Lewis B., 4450 East Admiral Place, Tulsa 15, Oklahoma *15AF-3*
Roberts, L. F., 417 Dunwody Drive, Pensacola, Florida *33AF-3*
Roberts, Martin Braddock, 2498 Pineview Drive, Decatur, Georgia *6M-1*
Roberts, Merle E., Bell Sound Division, Thompson Ramo Wooldridge, Incorporated, 555 Marion Road, Columbus 7, Ohio *1M-1*
Roberts, Robert A., Aladdin Industries Incorporated, 705 Murfreesboro Road, Nashville, Tennessee *73M-3*
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Roberts, S. D., Western Electric Company, Lexington Road, Winston-Salem, North Carolina *21A-2*
Roberts, Stanley E., Western Electric Company, 2525 North Shadeland Avenue, Indianapolis 19, Indiana *65A-2*
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Roberts, Warren Hugo, 903 Van Ness Street, San Antonio 8, Texas *39A-2*
Robertson, Donald B., The Ohio Art Company, Bryan, Ohio *0A-1*
Robertson, D. Lindsey, 4901 Maple Road, Minneapolis 24, Minnesota *38A-2*
Robertson, Jack R., 1762 Fabrique Drive, Wichita 17, Kansas *56A-2*
Robertson, James C., 444 North Logan Avenue, Littleton, Colorado *32A-1*
Robertson, Hugh L., 274 Fig Avenue, Chula Vista, California *29M-3*
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Robinson, Herbert D., 23800 Greenwood Road, Euclid 17, Ohio *7M-1*
Robinson, Jack R., 13704 South Purche Avenue, Gardena, California *23A-1*
Robinson, James R., 5421 Tenth Court, S., Birmingham 12, Alabama *9A-2*
Robinson, Louis H., 1939 West Granville, Chicago 26, Illinois 25A-1
Robinson, Mark M., Jr., Tiffany Road, R.R. 1, Norwell, Massachusetts *30A-2*
Robinson, Patrick J., 15 Fraserwood Avenue, Suite 2, Toronto 10, Ontario, Canada *87M-3*
Robinson, Phillip E., 3107 Crosswood Drive, Nashville 14, Tennessee *73A-1*
Robinson, Ronald Francis, 463 Cedar Brook Road, Lynn, Massachusetts *30A-2*
Robinson, William C., 558 Gettysburg Road, San Antonio 1, Texas *39A-2*
Robinson, William E., 3243 Briggs Avenue, Alameda, California *12A-2*
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Robison, Stuart W., 536 Ninth Street, Trona, California *23M-4*
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Rodriguez, Pedro M., Zamboanga City, Philippine Islands *0A-1*
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Roessler, Frederick M., 530 Palm Avenue, Fresno, California *0A-1*
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Rogers, John J., 2112 North Grand Oaks, Altadena, California *23M-4*
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Rogers, Larry G., Canadian Cottons Limited, Cornwall, Ontario, Canada *87A-1*
Rogers, Millard, 725 Fourteenth, North, Seattle 2, Washington *20A-2*
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Rosenfelder, Gerald S., 369 Grover Cleveland Highway, Eggertsville 26, New York *49M-3*
Rosenfeldt, Martin E., Apartado 1387, Monterrey, Mexico *39A-2*
Rosenfelt, Lawrence L., 15 South Watson Street, Easton, Pennsylvania *77M-4*
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Ross, Arthur S., 333 Felix Road, Huntingdon Valley, Pennsylvania *31A-2*
Ross, Donald Lee, 1705 Saxton, Houston 18, Texas *22A-1*
Ross, James D., 330 North Gore, Webster Groves 19, Missouri *16A-2*
Ross, James R., 1214 Crestover Road, Graylyn Crest, Wilmington 3, Delaware *0A-1*
Ross, John G., Jr., 3227 Kimball Avenue, Toledo 10, Ohio *36A-2*
Ross, John L., 716 Fulton Avenue, Rochester, Indiana *0A-1*
Ross, John M., 1502 Caywood, Houston 24, Texas *22A-1*
Ross, John (Jack) N., 2061 Twenty-fifth Street, Cuyahoga Falls, Ohio *52A-2*
Ross, Philip C., 72 Herthum Road, Whitesboro, New York *85M-4*
Ross, Sidney J., Packard-Bell Electronics, 12333 West Olympic Boulevard, Los Angeles 64, California *23A-1*
Ross, Walter L., Star Route South, Ligonier, Pennsylvania *3M-3*
Ross, William B., 209 East Denison, Davenport, Iowa *46A-2*
Rosscup, Donald F., 171 Glendora, Long Beach 3, California *23A-1*
Rosse, John J., 505 Bainbridge Street, Brooklyn 33, New York *86A-2*
Rosser, John E., Jr., Supervisor, Engineering Work Measurement, Cleveland Electric Illuminating Company, 55 Public Square, Cleveland, Ohio *7A-2*
Rossi, Rinaldo D., Copperweld Steel Company, Box 1000, Glassport, Pennsylvania *3M-3*
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Rossitto, Vincent, 69 Mildrum Road, Berlin, Connecticut *75A-4*
Rosso, James A., McAlester Oil Mill Company, Fourteenth and Washington, Box 275, McAlester, Oklahoma *57M-4*
Rota, Gino L., Arica 641, Miraflores, Lima, Peru *0A-1*
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Roth, Charles J., 2526 Kellerman Avenue, Cincinnati 13, Ohio *8M-4*
Roth, Edwin R., Norton Air Force Base, DIR/MTN Engineer, Industrial Engineering Branch (MEJ), San Bernardino, California *78A-2*
Roth, Eric, 4179 Moraga Avenue, San Diego 17, California *29A-3*
Roth, Eugene, 17008 Invermere Avenue, Cleveland 28, Ohio *7A-2*
Roth, Jerome H., 1544 Section Street, Plainfield, Indiana *65AF-4*
Roth, Martin, Waterbury Garment Corporation, 215 Cherry Street, Waterbury, Connecticut *97AF-4*
Rothfeld, Paul, 49 Lyndon Road, Sharon, Massachusetts *30A-2*
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Rothwell, John J., 94 North Lakeside Drive, Birchwood Lakes, Medford, New Jersey *31A-2*
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Rountree, Charles W., Island Creek Coal Company, Holden, West Virginia *58M-4*
Rouse, J. T., Room 0127, Main Navy Building, Seventeenth and Constitution Avenue, N.W., Washington 25, D.C. *14M-4*
Row, Harry S., Box 165, Baton Rouge 1, Louisiana *41A-1*
Rowane, John P. J., Morganite Incorporated, 33-2 Forty-eighth Avenue, Long Island City 1, New York *86A-2*
Rowbotham, Charles F., 8366 Fullbright Avenue, Canoga Park, California *23A-1*
Rowe, Alan J., 2169 Linda Flora, Los Angeles 24, California *23M-4*
Rowe, Michael B., 405 Fourth Street, S.W., Hickory, North Carolina *21A-2*
Rowe, William W., 2001 Thomas Place, Ft. Worth 7, Texas *10A-3*
Rowell, James H., 1315 Burry, Joliet, Illinois *25A-3*
Rowits, Robert E., Rubbermaid Company, 1205 East Bowman Street, Wooster, Ohio *52A-2*
Rowland, Clarence A., 3813 William Way, Sacramento 21, California *43A-2*
Rowland, Grattan W., Jr., 1104 Rosedale Road, N.E., Atlanta 6, Georgia *6A-2*
Rowlandson, John D., Manager, Time Standards, Sangamo Company, Limited, Laird Drive, Leaside, Ontario, Canada *87A-1*
Rowley, Richard Yates, 1020 Chestnut Hill Drive, Erie, Pennsylvania *51A-2*
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Rubel, Joel, 7846 Yamini Drive, Dallas 30, Texas *10A-1*
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Ruderfer, Sheldon H., 7119 Shore Road, Brooklyn 9, New York *5A-2*
Rudkin, Donald A., 217 Oak Lane, Cranford, New Jersey *61M-4*
Rudman, Albert J., 9146 Essex Avenue, Chicago 17, Illinois *25A-3*
Rudolf, Lawrence W., 5045 Alabama, St. Louis 11, Missouri *16AF-4*
Rueda, Ricardo, Cra 13, Number 13-73, Bogotá, Colombia, South America *0A-1*
Ruelius, Peter C., Jr., 93-17 Seventy-first Drive, Forest Hills 75, New York *5M-4*
Rueter, William E., 23350 Meadow Park Drive, Detroit 39, Michigan *47A-2*
Ruff, Geoffrey M., 809 Salem Street, Aurora, Colorado *32A-3*
Ruff, Wallace G., 717 Taylor, Richland, Washington *67A-1*
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Runyon, Horace C., 8013 Manire Drive, Houston 24, Texas *22M-4*
Rupert, Jack G., 7404 Canterbury, Prairie Village 15, Kansas *92A-2*
Ruppelt, Charlotte V., 4958 Coro Cove, Coro Lake, Memphis 9, Tennessee *28A-4*
Rupy, Stanley B., 3309 Coleridge Drive, Raleigh, North Carolina *66A-1*
Rush, Eli F., 4927 Valerie Street, Bellaire 101, Texas *22A-1*
Rushton, Kellogg, 519 Old Trail Road, Augusta, Georgia *0A-1*
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Russ, Raymond W., 420 Washington Street, Denver, Colorado *32M-3*
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Russell, James B., 14 Washington Street, Carbondale, Pennsylvania *0A-1*
Russell, Robert E., 1605 Dodson Drive, S.W., Atlanta 11, Georgia *6A-2*
Russell, Ross A., 302 Poplar Avenue, N.W., Canton 8, Ohio *19M-3*
Russon, Charles N., 2650 Nineteenth Street, Columbus, Indiana *65M-4*
Rust, Philip G., Jr., Rt. 3, Thomasville, Georgia *0A-1*
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Ryan, Robert S., Columbia Gas System Service, 1600 Dublin Road, Columbus 12, Ohio *1M-4*
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Rynd, Wilbur B., 3908 Sanquinet Street, Ft. Worth 7, Texas *10M-3*

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Sabot, Peter, 1644 Twenty-first Street, N.W., Washington 9, District of Columbia *14A-2*
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Sachs, John H., 10 Hillside Avenue, New York 40, New York *5A-2*
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Sandford, William A., William Neilson-Toronto, *299* Gladstone Avenue, Toronto 9, Ontario, Canada *87M-3*

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Sanoh, Akira, 3 Kohama-higashi, Sumiyoshi, Osa, Japan *0A-1*

Santner, Ulrich G., Unternberg 46, Tamsweg, Austria *0A-1*

Santorella, Alexander M., Hinde and Dauch Paper Company, Division of West Virginia Pulp and Paper, 550 Ninth Street, Hoboken, New Jersey *61A-2*

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Sarno, Gregory F., 2860 Buhre Avenue, New York, Bronx 61, New York *5A-2*

Sartor, Thomas B., 829 North Water Avenue, Sharon, Pennsylvania *24M-3*

Sasaki, Robert S., 920 West Marietta Street, Los Angeles 23, California *23A-1*

Satten, Mortimer, 6005 Henderson Drive, La Mesa, California *29A-3*

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Sauer, Howard A., 217 Taylor Road, Honeoye Falls, New York *44A-2*

Sauers, Glenn E., Jr., 1423 Jefferson Avenue, N.W., Canton 8, Ohio *19A-1*

Sauget, Vincent L., 143 North Eighty-first Street, Belleville, Illinois *16M-4*

Saunders, Byron W., College of Engineering, Cornell University, Ithaca, New York *48M-3*

Saunders, George E., 2529 Northwest Forty-four, Oklahoma City 12, Oklahoma *57A-2*

Saunders, Jay S., 4020 Valley Ridge Road, Dallas 20, Texas *10M-3*

Saunders, Ronald P., 41 Harwood Road, Spencerport, New York *44A-2*

Saunders, Tazewell, Jr., 8623 Ashcroft Street, Dallas 31, Texas *10A-1*

Saunders, William B., 16 Roselawn, Caseyville, Illinois *16M-4*

Sauter, Laurence J., 8855 Humphrey Lane, Cincinnati 42, Ohio *8A-2*

Savarino, Joseph A., 29703 Grand Boulevard, Wickliffe, Ohio *7A-2*

Savitt, Arnold J., 28 Old Pond Road, Great Neck, New York *5A-2*

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Saylor, Paul D., 1459 East Rand, Hobart, Indiana *53A-1*

Scalise, George L., 606 Orchard Hill Drive, Louisville 14, Kentucky *18M-3*

Scamardi, Jack, 11209 Clematis Lane, Houston 35, Texas *22M-4*

Scanlon, Glenwood C., 8 Maple Avenue, M.R. 97, Binghamton, New York *96A-1*

Scarzella, Jack R., 54 Woodland Drive, Walnut Creek, California *12A-2*

Schachne, Stanley H., 233 West Eighty-third Street, New York 24, New York *5A-2*

Schacht, Neil, 2405 Crest Ridge, Dallas 28, Texas *10A-3*

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Schaefer, Julius L., 9 Northway, Hartsdale, New York *5M-4*

Schaefer, William J., 301 Mac Lane, Palo Alto, California *37M-4*

Schafer, Albert C., 244 Windsor Avenue, Urbana, Ohio *0A-1*

Schafer, Frederick E., 557 Allenby Avenue, Pittsburgh 18, Pennsylvania *3A-1*

Schafer, Ray E., 834 Towne Street, Costa Mesa, California *23AF-3*

Schaffer, Kenneth E., 65 Manor Drive, Newark 6, New Jersey *61A-2*

Schaffir, Kurt H., 310 East Seventy-first Street, New York 21, New York *5M-4*

Schaffir, Walter B., 63 Scudders Lane, Glen Head, Long Island, New York *5M-4*

Schainholz, Herbert, 80 Bennett Avenue, New York 33, New York *5A-2*

Schancupp, Marvin, 5 Driftway Road, Danbury, Connecticut *5A-2*

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Scheck, Timothy R., 525 Venado Vista Drive, La Canada, California *23A-1*

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Schehr, Leonard H., 3716 Downey Dale Drive, Randallstown, Maryland *42AF-4*

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Scheirer, Robert David, Jr., C. H. Masland and Sons, Carlisle, Pennsylvania *95M-4*

Scheirer, Russell E., Jr., 1036 Linden Street, Allentown, Pennsylvania *77M-4*

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Schell, Steadman B., Jr., 246 South Colonial Homes Circle, Atlanta 9, Georgia *6A-2*

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Schetky, Malcolm O., U.S.S. William M. Wood DDR 715, c/o FPO, New York, New York *0A-1*

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Schiltz, James C., Industrial City, P.O. Box 164, St. Joseph, Missouri *92A-2*
Schimke, Robert S., Consolidated Western Steel Division, South San Francisco Plant, 1 Butler Road, South San Francisco, California *37A-1*
Schindler, Earl F., Box 1031, Pearisburg, Virginia *81A-1*
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Schirmer, Robert F., E. I. DuPont, 30 East Ninth, Louviers Building, Wilmington 98, Delaware *100A-1*
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Schleif, Edward Llewellyn, 11 Kerr Avenue, Kensington, Berkeley 7, California *12M-4*
Schleif, Don C., Route 1, Daisy, Tennessee *54AF-4*
Schliffke, Carl C., Plant Industrial Engineer, Procter and Gamble Manufacturing Company, Nineteenth and Kansas Avenue, Kansas City 5, Kansas *92M-4*
Schlinkmann, William A., Allen-Bradley Company, 136 West Greenfield Avenue, Milwaukee 4, Wisconsin *45A-2*
Schloemann, James C., 219 Frost Avenue, Ferguson 21, Missouri *16A-2*
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Schmidley, Richard N., 1127 Lincoln, Peru, Illinois *80AF-4*
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Schmitz, Robert A., USS Fessenden (Der 142), c/o Fleet Post Office, San Francisco, California *0A-1*
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Schneider, George M., 3062 McKinley Drive, Santa Clara, California *37M-4*
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Schneider, John, 711 La Salle Drive, Endwell, New York *96A-1*
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Schock, J. Frederick, Leeds and Northrup Company, 4901 Stenton Avenue, Philadelphia 44, Pennsylvania *31M-4*
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Schoeller, V. Donald, Director Management Development, Remington Rand, 1 Atlantic Street, Stamford, Connecticut *5M-4*
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Schoenfeldt, Emil C., Sinclair Pipe Line Company, Sinclair Building, Independence, Kansas *0M-3*
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Schulz, Eugene J., 6425 Fernhurst Avenue, Cleveland 30, Ohio *7A-2*
Schultz, Gary E., Thirteenth Street, Box 373, West Point, Virginia *0A-1*
Schultz, Lawrence F., 952 Stannage Avenue, Albany 6, California *12M-4*
Schultz, Robert G., 2443 Ardmore Manor, Winston-Salem, North Carolina *21A-4*
Schultz, William H., 1417 South Eighth West, Woods Cross, Utah *50A-2*
Schultz, William R., 2677 Fairland Street, Cuyahoga Falls, Ohio *52M-4*
Schulz, Ernst, 6325 Ravendale Lane, Dallas 14, Texas *10M-3*
Schuyler, E. Glenn, Box 11012, Dallas 23, Texas *10A-3*

Schwamm, Carl L., Jr., 7515 Indiana Road, Toledo 12, Ohio *36AF-4*
Schwan, Alferd P., John Deere Plow Works, 1225 Third Avenue, Moline, Illinois *46AF-4*
Schwan, Harry T., 2425 Meadow Road, N., Wilmette, Illinois *25M-4*
Schwantes, John Warren, Binks Manufacturing Company, 3114 Carroll Avenue, Chicago 12, Illinois *25M-4*
Schwantes, Wilbert H., 4719 North Forty-sixth Street, Milwaukee 16, Wisconsin *45A-2*
Schwartz, Allan M., Industrial Engineer, Westinghouse Electric Corporation, 1216 West Fifty-eighth Street, Cleveland 1, Ohio *7A-2*
Schwartz, Arthur, 2416 Menokin Drive, Apartment 201, Alexandria, Virginia *14A-2*
Schwartz, Herbert O., 6 Gruenther Court, Rockville, Maryland *14A-4*
Schwartz, Herbert S., 82 Hayes Road, Glen Lenox, Chapel Hill, North Carolina *66AF-3*
Schwarz, Robert R., 17 Parkhill Avenue, Millbury, Massachusetts *68M-3*
Schwegman, Merlin D., 8291 South Moody, Buena Park, California *23M-4*
Schweinhart, Maurice E., 1617 Nightingale Road, Louisville 13, Kentucky *18A-3*
Schweizer, Robert L., 515 Washington Highway, Synder 26, New York *49A-1*
Schwendemann, Edward T., Inland Steel Company, 3210 Watling Street, East Chicago, Indiana *53M-3*
Schwedinger, Royal O. G., 331 Orchard, Webster Groves, Missouri *16M-4*
Schwind, William A., 117 Polk Street, Burlington, Iowa *0A-1*
Schwing, Richard E., 1160 York Street, Apartment 1, Pittsburg, California *12A-2*
Schwinne, Carl E., 658 Seymour Avenue, Columbus 5, Ohio *1A-2*
Schwint, Kenneth F., 32 Birch Lane, Plainview, New York *86A-2*
Sciabbarrasi, Sebastian A., P.O. Box 3142, San Antonio 11, Texas *39A-2*
Sciangula, George F., 511 Madison Avenue, York, Pennsylvania *72A-2*
Sciarro, Stephen, Jr., Fairview Road, Westboro, Massachusetts *68A-2*
Sciolino, Samuel, 365 Newburgh Avenue, Buffalo 15, New York *49A-1*
Scocca, Armand M., 30 Revere Road, Apartment 8, Drexel Hill, Pennsylvania *31A-2*
Scofield, J. Wayne, 5 Linwood Drive, Marshall, Texas *60M-4*
Scoggins, Convers D., 8069 Sholar Drive, Baton Rouge 8, Louisiana *41A-1*
Scott, Billy H., 1700 Vinewood, Ft. Worth, Texas *10A-1*
Scott, Ervin E., 1910 Northwest Eighth Street, Oklahoma City 6, Oklahoma *57A-2*
Scott, John, III, 4074 Navajo Trail, Atlanta 19, Georgia *6M-4*
Scott, Preston H., 3364 Ewald Circle, Detroit 38, Michigan *47AF-4*
Scott, Ronald A., Eighth Signal Battalion, APO 111, New York, New York *0A-1*
Scott, Thomas A., 5816 Wheaton Drive, Ft. Worth 15, Texas *10M-3*
Scott, Vern D., 3701 South Main, Independence, Missouri *92A-2*
Scott, Walter, Jr., 56 Delaware Avenue, Freeport, New York *86A-4*
Scribner, Harry E., R.R. 19, Box 243B, 4045 East Seventy-seventh, Indianapolis 20, Indiana *65A-2*
Scull, Lynn C., Watchung Avenue, Madison, New Jersey *61A-2*
Scully, Richard L., 6130 North Legett, Chicago 46, Illinois *25A-1*
Searle, Robert E., Bronze Heights, Caldwell, Ohio *7M-4*
Sears, James A., 5600 Clairidge, Willoughby, Ohio *7A-2*
Seashore, Richard P., 3665 Fillmore, San Francisco 23, California *12A-2*
Seastrom, Walter E., 6239 Mosley Avenue, Los Angeles 56, California *23M-4*
Sebell, Adolph L., Syracuse Ornamental Company, Syracuse, New York *13M-4*
Seberg, Frank J., 4133 Forty-seventh Avenue, S., Seattle 18, Washington *20M-4*
Seccia, Arthur C., 63 Sandy Hollow Road, Port Washington, Long Island, New York *5M-4*
Secord, Kenneth C., 15 Nimrod Drive, Concord, Massachusetts *30M-4*
Sedelmeier, Joseph H., 1645 Thirty-first Street, N.E., Canton 4, Ohio *19AF-3*
Sedenka, Oldry, B. F. Drakenfeld and Company, Incorporated, Box 519, Washington, Pennsylvania *0M-3*
Sedgwick, Edward V., 220 Bently Circle, Los Angeles 49, California *23AF-3*
Sedlacek, Frank J., 1432 Timberline Drive, Bettendorf, Iowa *46A-4*
See, George C., 810 North Twenty-eighth Street, Orange, Texas *0A-1*
Seeger, Frank L., 7150 Washington Avenue, University City 5, Missouri *16M-4*
Seelbach, Donald E., 75 De Santis Drive, Columbus 14, Ohio *1A-4*
Seeley, Donald E., 103 Linabary Avenue, Westerville, Ohio *1A-2*
Seeley, Merrill W., Hoerner Boxes, Incorporated, Main Street Road, Keokuk, Iowa *0A-1*
Seelig, M. Donald, 143 Warren Avenue, Chelmsford, Massachusetts *30A-2*
Seetharaman, K., Industrial Engineering Department, Telco, Jamshedpur-4, India *4A-S*
Segal, Perry, 1701 Sherwood Avenue, Apartment D, Baltimore 14, Maryland *42M-4*
Segale, Clement L., Jr., 97-01 One Hundred Thirty-fifth Road, Ozone Park, New York *5A-4*
Segerstrom, Ake, c/o Cia Chilena de Fosforos, Casilla 1835, Santiago, Chile *0A-1*
Seggel, Lawrence R., 1515 McCullough Avenue, N.E., Huntsville, Alabama *69A-2*
Seggelin, Lawrence N., Bethlehem Steel Company, Fore River Shipyard, Howard Street, Quincy, Massachusetts *30A-2*
Sehlmeyer, Ernst G., 462 Deodora Drive, Los Altos, California *37A-1*
Seibert, Edwin A., 2157 East Maxwell Avenue, Evansville 11, Indiana *88A-2*
Seidenberg, Robert J., 208-26 Grand Central Parkway, Queens Village 27, New York *5A-2*
Seidler, Isidor B., 10 Crescent Lane Roslyn Heights, New York *5M-4*
Seif, Donald W., 620 Arlington Avenue, McKeesport, Pennsylvania *3A-1*
Seifert, Albert Jacob, 3173 Stockton Avenue, Palo Alto, California *37M-4*
Seigler, Irwin S., Jr., P.O. Box 65, Summerville, South Carolina *0A-1*
Seinsheimer, Walter G., 706 Terrace Hilton Building, Cincinnati 2, Ohio *8M-4*
Seitz, L. Raymond, 2429 Crystal Lane, York, Pennsylvania *72A-2*
Seitzler, Henry E., 1955 Lakehills Parkway, Baton Rouge 8, Louisiana *41AF-3*
Sekela, George, 13632 Rockside Road, Garfield Heights, Ohio *7M-4*
Selden, Chester J., 24831 Crowley Avenue, Taylor, Michigan *47A-2*
Selig, John D., 515 Stilwell, DeQueen, Arkansas *84A-1*
Sell, Milton T., 402 Herrick Avenue, E., Wellington, Ohio *7M-4*
Sellenings, John S., Johns Manville Fiber Glass, Incorporated, Third and Perry Streets, Defiance, Ohio *36A-4*
Sellers, Albert R., 251 Tolbert Street, Wadsworth, Ohio *52A-2*
Sellie, Clifford N., Standards Engineering Company, 7446 North Western, Chicago 45, Illinois *25M-4*
Selman, Jerome H. N., Chemical Corps, United States Army, New York Chemical Procurement Dist., 290 Broadway, New York 7, New York *5M-4*
Selogie, Louis A., 10241 Aura Avenue, Northridge, California *23M-4*
Seltzer, Sol, 3091 Edwin Avenue, Ft. Lee, New Jersey *5A-2*
Semmler, Robert W., 17720 Bennington Drive, Brookfield, Wisconsin *45M-4*
Semplinski, Edward, 5527 Van Buren, Gary, Indiana *53A-1*
Senes, John J., 32 East Mankate, Chula Vista, California *29A-1*

Senters, Frank J., 211 Sunset Drive, Westfield, New Jersey *5M-4*
Seperack, Reinhold J., 3706 North Charles Street, Baltimore 18, Maryland *42A-2*
Serado, John J., 5828 Eastern Avenue, N.E., Washington, District of Columbia *14A-2*
Serenbetz, Warren L., Chief Engineer, Railway Express, 219 East Forty-second Street, New York 17, New York *5M-4*
Sertl, Clifford A., 33 Shire Oaks Drive, Pittsford, New York *44A-2*
Sespaniak, Lawrence J., Benedict Drive, R.F.D., Wapping, Connecticut *75A-2*
Settle, Joseph E., Qtrs. S-705, Ft. Story, Virginia Beach, Virginia *66A-1*
Seward, Thomas F., 2118 South Bellaire, Denver 22, Colorado *32A-1*
Seybert, Robert E., ACF Industries, Incorporated, Ninth and Oak Streets, Berwick, Pennsylvania *89M-3*
Seymour, Jack, 4818-A Eastwood Street, Wichita 18, Kansas *56A-2*
Shadeck, James L., 337 East Curtin Street, Bellefonte, Pennsylvania *89A-2*
Shadle, William D., 25763 Yeoman Drive, Westlake, Ohio *7A-4*
Shafer, Clayman C., 48 Pilgrim Path, Huntington, Long Island, New York *86M-4*
Shafer, James D., 1642 North Garland, Wichita 3, Kansas *56A-2*
Shafer, Raymond E., Department of Industrial Engineering, West Virginia University, Morgantown, West Virginia *58M-4*
Shafer, Rodney Dwain, 105 Western Avenue, Morgantown, West Virginia *0A-1*
Shaffer, Daniel T., 23 West Mahoning Street, Danville, Pennsylvania *89A-2*
Shaffer, Lester S., Rockwell Manufacturing Company, 401 Newell Street, Barberton, Ohio *52M-4*
Shaffer, Max E., 1215 Emerson Street, Palo Alto, California *37A-3*
Shafran, Robert, 415 Grape Street, Vineland, New Jersey *31M-4*
Sheilds, B. J., 4725 North Newcastle, Harwood Heights 31, Illinois *25A-1*
Shakun, Melvin F., 95 Grand Avenue, Rockville Centre, New York *5M-4*
Shallcross, Thomas J., 279 East Madison Street, Elmhurst, Illinois *25A-1*
Shalvarjian, Haig J., 1723 Woodland, Palo Alto, California *37A-3*
Shamel, Charles D., American Sugar Refining Company, 7417 North Peters Street, Arabi, Louisiana *74A-2*
Shane, Norman A., Jr., Shane Manufacturing Company Incorporated, Evansville 7, Indiana *88M-4*
Shane, William J., Industrial Engineering Department, West Bend Aluminum Company, West Bend, Wisconsin *45M-4*
Shaner, Donald R., 1213 Golf Lane, Wheaton, Illinois *25A-1*
Shank, John M., Springfield Armory, Springfield, Massachusetts *94M-4*
Shanks, Thomas Albert, E. I. DuPont, Rayon Plant, Old Hickory, Tennessee *73M-3*
Shannon, Robert E., 2027 Delbrook Drive, Huntsville, Alabama *69A-2*
Shannon, William G., 841 Larry Lane, Decatur, Georgia *6A-2*
Shapiro, Robert N., 213-02 Seventy-fifth Avenue, Bayside 64, New York *5A-2*
Shapton, William R., 67 Root Street, New Hartford, New York *85A-2*
Sharbaugh, Ronald E., 1506 Ninteenth Avenue, Altoona, Pennsylvania *0A-1*
Shares, Floyd W., Stromberg-Carlson Company, 100 Carlson Road, Rochester 3, New York *44A-2*
Sharp, C. B., 823 Ross Trail, Arlington, Texas *10A-3*
Sharp, Lee S., 8258 Doris Street, San Gabriel, California *23M-4*
Sharrar, Thomas W., 5200 Crestwood Drive, Harrisburg, Pennsylvania *95A-2*
Shattuck, Glenn A., RFD, Staatsburg, New York *76A-2*
Shattuck, Ronald S., 1635 Riverside Drive, Fullerton, California *23A-1*
Shatz, Benjamin J., 5943 Ogontz Avenue, Philadelphia 41, Pennsylvania *31A-2*
Shaver, Robert M., 4625 Park Avenue, Indianapolis 5, Indiana *65AF-4*
Shaw, C. George, P.O. Box 18, Provo, Utah *50M-4*
Shaw, Charles S., 556 East Harmon Drive, Midwest City, Oklahoma *57A-2*
Shaw, G. Merrill, 2009 West 5850 South, Roy, Utah *50A-2*
Shaw, Harold M., Industrial Engineer, Philadelphia Gas Works, 1800 North Ninth Street, Philadelphia 22, Pennsylvania *31M-4*
Shaw, Irving, 223 Prospect Street, Building 4, Apartment 2A, East Orange, New Jersey *61A-2*
Shaw, Leonard S., 4440 North Hazel Street, Chicago 40, Illinois *25A-1*
Shaw, Murray H., 5700 Wedgeworth, Ft. Worth, Texas *10A-3*
Shea, Thomas B., 264 Gillette Avenue, Springfield 8, Massachusetts *94M-4*
Shearer, George L., The Standard Register Company, Mt. Zion Road, York, Pennsylvania *72M-4*
Shearer, John B., Jr., 3522-B, Springhill Extension, Mobile, Alabama *79A-2*
Shearer, Robert J., 60 Stock Avenue, Toronto 18, Ontario, Canada *87M-3*
Sheehan, John Kavitt, 1309 McCausland Avenue, St. Louis 17, Missouri *16A-2*
Sheeran, F. Burke, 995 West "K" Street, Benicia, California *12A-2*
Sheerer, Martin W., 121 Oakland Avenue, Pittsburgh 13, Pennsylvania *3A-1*
Sheets, Richard S., Corhart Refractories Incorporated, 1600 West Lee Street, Louisville, Kentucky *18A-1*
Shelley, Adrian D., 328 Oak Drive, Rock Hill, South Carolina *0A-1*
Shelton, Bern E., 4583 Dubourg Lane, St. Louis 28, Missouri *16A-2*
Shelton, E. Dayle, 2325 East Stafford, Wichita 11, Kansas *56A-2*
Shelton, John R., Chairman, Operating Standards Division, The Port of New York Authority, 111 Eighth Avenue, New York 11, New York *5M-4*
Shenkin, Gerald, 977 Grant Avenue, New York 56, New York *5A-2*
Shepherd, George H., 182 Wray St., Athens, Georgia *0A-1*
Shepard, Irby C., Jr., 7 Watson Drive, Newnan, Georgia *6A-2*
Shepard, John W., 9 Day Street, North Easton, Massachusetts *30AF-4*
Sherburne, Henry N., 211 Bainbridge Avenue, Pensacola, Florida *33M-3*
Sherck, D. L., USS Evans (DE 1023), c/o FPO, San Francisco, California *0A-1*
Shereff, Bernard, 3210 Arlington Avenue, New York 63, New York *5M-4*
Sheridan, Thomas M., Cuba Road, Stone Hall, Cockeysville, Maryland *42A-2*
Sherlock, John G., Western Industry Magazine, 609 Mission Street, San Francisco, California *12AF-3*
Sherman, Arthur F., 17 Lincoln Circle, Andover, Massachusetts *62M-4*
Sherman, Irving A., 1304 Central Avenue, Union City, New Jersey *61A-2*
Sherman, John K., Jr., 607½ Park Terrace, Greensboro, North Carolina *0A-1*
Shermer, Allen V., Yadkinville, North Carolina *21A-2*
Sherwood, Albert B., Lake Road, Seneca Falls, New York *0A-1*
Shettles, Mack W., 2921 Azalea Road, S.W., Huntsville, Alabama *69A-2*
Shetty, C. M., Industrial Engineering Department, Northwestern University, Evanston, Illinois *25A-1*
Shewbridge, William H., Scoville Manufacturing Company, 99 Mill Street, Waterbury, Connecticut *97M-4*
Shields, James D., 454 Glenmont Avenue, Columbus 14, Ohio *1A-2*
Shields, Royal S., 4940 Plymouth View Drive, Murray 7, Utah *50A-2*
Shiffler, Paul M., Thompson Ramo Woolridge, Incorporated, 601 East Market Street, Danville, Pennsylvania *89A-2*
Shigekawa, David G., 18485 Montpene Way, Saratoga, California *37A-1*
Shiltz, Paul W., 830 Elmwood, North Canton 20, Ohio *19A-1*

Shimer, William B., 32096 Rosevear Drive, Birmingham, Michigan *47A-2*
Shiner, Clyde Riley, 3904 East Douglas, Wichita 8, Kansas *56M-4*
Shinn, Tyler, A., c/o General Electric Company, 1103 Central Avenue, Phoenix, Arizona *70M-4*
Shipley, Robert B., 328 Kachina Lane, Scottsdale, Arizona *70A-2*
Shira, Neil H., 2935 Kirkhaven Drive, Youngstown 11, Ohio *24M-3*
Shirar, Paul T., Eaton Manufacturing Company, Axle Division, 739 East One Hundred Fortieth Street, Cleveland 10, Ohio *7M-4*
Shirtz, Raymond L., 662 Hawarden Road, Springfield, Pennsylvania *31A-2*
Shissias, James A., 21 South Thirty-eighth Street, Camden 5, New Jersey *31A-2*
Shock, Rogers T., 641 North Poplar, Fostoria, Ohio *36M-4*
Shook, Charles, 4629 Branscomb, Corpus Christi, Texas *0A-1*
Shornhorst, Robert J., 4009 Habana Avenue, Jacksonville 7, Florida *27A-2*
Short, DeVoine E., 731 Ridgehaven Drive, La Habra, California *23AF-3*
Short, Donald E., Box 21, Dayton, Indiana *35M-4*
Short, J. Landon, 158 Lake Drive, E., Packanack Lake, Wayne, New Jersey *61M-4*
Shortridge, Elmer P., 3511 Loganview Drive, Dundalk 22, Maryland *42A-2*
Shortt, Elmer P., 2300 East Beverly Road, Shorewood 11, Wisconsin *45AF-4*
Shotwell, Irwin C., Jr., 410 Southeast Ninty-fourth Street, Vancouver, Washington *0A-1*
Shoumatoff, Nicholas, West Virginia Pulp and Paper Company, 230 Park Avenue, New York 17, New York *5M-4*
Shretter, Martin, 264 West Forty-first Street, Shadyside, Ohio *3A-1*
Shroff, Arvind R., Apartment 403, 401 East Thirty-second Street, Chicago 16, Illinois *25A-1*
Shropshire, John G., 326 Fox Hill Road, Hampton, Virginia *99A-2*
Shuff, Auburn D., 2153 Pleasant Valley Drive, Huntington, West Virginia *58AF-4*
Shukas, Albert T., P.O. Box 1337, Hayden, Arizona *70M-4*
Shuler, Joe H., 1514 Smith Road, Charleston, West Virginia *58A-2*
Shull, Ted K., 1515 Woodcrest Circle, Harrisburg, Pennsylvania *95A-2*
Shumaker, Clifford H., Southern Methodist University, Dallas, Texas *10M-3*
Shuster, Russell E., 8184 Craig Lane, Brecksville, Ohio *7M-4*
Sibson, David S., Olive Street, Ashland, Massachusetts *30M-4*
Siddall, Dan, Jr., 110 Jewel Drive, Longview, Texas *60A-2*
Sideris, Xen N., 202 Contentnea Street, Greenville, North Carolina *66A-1*
Siderwitch, John J., 4930 North David Street, Indianapolis 26, Indiana *65A-2*
Sieck, Herbert, 1160 Miller Avenue, Berkeley 8, California *12A-4*
Siefert, Norman G., 904 South State, Springfield, Illinois *16A-2*
Siegel, Bernard L., 215-30 Forty-seventh Avenue, Bayside, Long Island 61, New York *5A-2*
Siegel, Charles, Kearfott Company, Route 70, Black Mountain, North Carolina *83A-2*
Siegel, Maxwell E., 18 Abingdon Square, New York 14, New York *5A-2*
Siegel, Ralph, 2819 Morris Avenue, New York 68, New York *5A-2*
Siemens, Herman W., Aluminum Company of Canada, Limited, Arvida, Quebec, Canada *0M-3*
Signorelli, Richard L., 60 Calhoun Street, Torrington, Connecticut *97A-2*
Sik, Albert, Jr., 4960 Richmond Road, Warrensville Heights 28, Ohio *7A-2*
Sikes, Ralph S., 29 Peachtree Avenue, N.E., Atlanta 5, Georgia *6A-2*
Sikora, Eugene S., 531 Windsor, Lakeland, Florida *0A-3*
Sikorski, Richard A., Industrial Engineer, Lester Engineering Company, 2711 Church Avenue, Cleveland 13, Ohio *7AF-4*
Silon, Herbert, 3403 Rowena Road, Louisville 5, Kentucky *18A-1*
Siltanen, John C., 101 Prospect Avenue, Hackensack, New Jersey *5M-4*
Silva, Antonio R., Avenida El Paseo Number 19, Los Rosales-Caracas, Venezuela *0A-1*
Silver, Alvin M., 1 Thrush Lane, Levittown, Long Island, New York *5A-2*
Silver, Norman, 16-34 One Hundred Sixty-sixth Street, Whitestone 57, New York *5A-4*
Silver, William E., 1723 Greenwich Street, San Francisco 23, California *12A-2*
Silverstein, Marshall, 503 Valley View Apartments, Sixteenth and Elm Streets, Allentown, Pennsylvania *77A-2*
Silvera, Raymond L., Owens Illinois Glass Company, 3600 Alameda Avenue, Oakland, California *12AF-3*
Silvoy, Edward F., 2608 Hillegas Road, Ft. Wayne, Indiana *34A-1*
Simmons, Wilberforce D., Western Union Telegraph Company, 60 Hudson Street, New York City, New York *5A-2*
Simon, Leonard S., Germanon-Simon Machinery Company, Incorporated, 408 St. Paul Street, Rochester 3, New York *44A-2*
Simon, Louis M., 1861 Lincoln Avenue, East Meadow, Long Island, New York *86A-4*
Simon, Sheldon, 34 Longview Drive, Tuckahoe 7, New York *5A-4*
Simon, Victor, 290 Madison Avenue, New York 17, New York *5A-2*
Simmons, Oscar W., 17 Burley Circle, Cincinnati 18, Ohio *8A-2*
Simonetti, Frank L., 2438 Ridgewood Road, Akron 13, Ohio *52M-4*
Simonton, Frederick H., 6900 South Crandon Avenue, Chicago 49, Illinois *25M-4*
Simpelaar, Howard Milton, 4121 West Martin Drive, Apartment 204, Milwaukee 8, Wisconsin *45M-4*
Simson, Bruce R., Karlin Road, Mounted Route, Rome, New York *85A-2*
Simpson, Charles L., 1211 Westwood Avenue, Chattanooga 5, Tennessee *54A-2*
Simpson, Richard C., 4212 Franklin, Des Moines, Iowa *0A-1*
Simpson, William B., 98-10 Sixty-fourth, Rego Park 74, New York *5M-4*
Sims, David F., Apartment A-2, 123 Acme Street, Elizabeth, New Jersey *61A-2*
Sims, E. Ralph, Jr., Consulting Industrial Engineer, P.O. Box 239, Lancaster, Ohio *1M-4*
Sims, James W., 4829 Southern Avenue, S.E., Albuquerque, New Mexico *59M-3*
Sims, William R., 6602 Southside Drive, Louisville, Kentucky *18M-3*
Simunic, Frederick J., 7005 Delaware, Crown Point, Indiana *53A-1*
Sinclair, Clifford F., 172 West G Street, Benicia, California *12AF-3*
Sinclair, Donald R., 301 East Two Hundred Eighteenth, Euclid 23, Ohio *7M-4*
Sinclair, Frank, Jr., 612 Elaine Drive, Irving, Texas *10A-1*
Sinding, Steven W., Hudson Pulp and Paper Corporation, 477 Madison Avenue, New York 22, New York *5M-4*
Singh, B., P. W. and G. Mills Company, Limited, P.O. Kharar near Chandigarh, India *4AF-S*
Sinni, William B., 2541 Cudaly Street, Walnut Park, California *23AF-3*
Siniard, Jerry L., 1116 Choice Street, Gadsden, Alabama *0A-1*
Sinke, Donald A., 9033 North Greenvale, Milwaukee 17, Wisconsin *45M-4*
Sipfle, James A., 2735 Ninth Avenue, Rock Island, Illinois *46AF-4*
Siria, Villa W., 687 Fig Avenue, Chula Vista, California *29A-1*
Sirianni, Nicola C., 555 Arizona Drive, New Kensington, Pennsylvania *3A-1*
Sirker, S. P., Industrial Engineering Department, TISCO Jamshedpur—1, India *4M-S*
Sisco, Robert C., Production Control Supervisor, East Bay Municipal Utility District, P.O. Box 4616, Oakland 23, California *12M-4*
Sisson, Arthur L., Jr., 6114 Lone Oak Drive, Bethesda, Maryland *14M-4*

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Sitaras, George, Otis Elevator Company, 44 Wells Avenue, Yonkers, New York *5A-2*
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Skedzeleski, Karol A., 1360 Hialeah Place, Florissant, Missouri *16A-4*
Skers, Walter A., 34 Berger Street, Emmaus, Pennsylvania *77M-4*
Skillman, Herbert E., 410 East Fifty-fifth Street, Indianapolis 20, Indiana *65A-2*
Skinner, Edward T., 4307 Beechwood Lane, Dallas 20, Texas *10A-3*
Skiver, Kenneth W., 1126 Montrose, Toledo 7, Ohio *36AF-4*
Skoran, Thomas E., Pine Tree Lane, R.F.D., Wapping, Connecticut *75A-2*
Slabbaert, Romain A., 5606 Berry Creek, Houston 17, Texas *22A-1*
Slack, Ernest E., Room 105, C and O Shops, Twenty-sixth and Eighth Avenue, Huntington 1, West Virginia *58A-2*
Slagle, Albert H., 8812 Signature Lane, Crestwood 26, Missouri *0A-1*
Slagle, E. L., 32 Cambridge Court, Danville, California *12M-4*
Slater, Robert L., 5402 Nebraska Avenue, Toledo 7, Ohio *36AF-4*
Sleaford, William A., 20 Lincoln Street, Maynard, Massachusetts *30A-2*
Sledge, Alexander, College of Engineering, Rutgers University, New Brunswick, New Jersey *61A-2*
Sleeper, Donald C., 18 Tice Valley Court, Walnut Creek, California *12A-2*
Sloan, Donald M., Plant Industrial Engineer, Georgia Rug Mill, Summerville, Georgia *93A-2*
Sloan, Erwin Haskel, 936 Red Road, Teaneck, New Jersey *5A-2*
Sloan, Joseph, 345 Congress Avenue, Lansdowne, Pennsylvania *31A-2*
Slott, Irving, 6528 Cocos Drive, Orlando, Florida *27A-2*
Slovick, Thomas W., 2029 West Kendon Drive, Pittsburgh 35, Pennsylvania *3M-3*
Smailer, Albert D., 6508 Ponderosa N.E., Albuquerque, New Mexico *59M-3*
Small, George N., O'Neil Drive, Westboro, Massachusetts *68A-2*
Smalley, Harold E., School of Industrial Engineering, Georgia Institute of Technology, Atlanta 13, Georgia *6M-4*
Smallman, Alan, Personnel Administrator P. M. Limited, 34 Queens Road, Melbourne, Victoria, Australia *0A-1*
Smart, Charles E., 38 Maple Avenue, Troy, New York *0AF-3*
Smeltzer, Virgil L., 2520 Phelps Avenue, Cuyahoga Falls, Ohio *52A-2*
Smetana, Fred, 3813 Grant Street, Reiffton, Reading, Pennsylvania *0A-1*
Smiles, Wilbur J., 407 Luzerne Avenue, West Pittston, Pennsylvania *0A-1*
Smiley, Lloyd G., 23 Skyview Drive, Poughkeepsie, New York *76M-4*
Smith, Avery C., 611 Northeast Fifty-first Street, Miami 37, Florida *40A-3*
Smith, Billy P., 104 South Seaman, Eastland, Texas *0A-1*
Smith, Chelten W., Jr., 710 Ravine Street, Meadville, Pennsylvania *51AF-4*
Smith, Chester F., Industrial Engineer, American Biltrite Rubber Company, 22 Willow, Chelsea, Massachusetts *30A-2*
Smith, Clarence R., R.D. 2, West Willington, Connecticut *75M-4*
Smith, Clyde P., 11 Poplar Street, Rome, Georgia *93M-4*
Smith, Dale M., 1712 Flora, North College Hill, Cincinnati 31, Ohio *8M-4*
Smith, Dan D., 218 North Harrington Drive, Fullerton, California *23A-3*
Smith, Donald C., Industrial Relations Assistant, Courtaulds (Alabama) Incorporated, P.O. Box 1076, Mobile, Alabama *79M-4*
Smith, Donald E., 3071 Wallace Road, Huntington 5, West Virginia *58A-2*
Smith, Douglas D., 857 West South Street, Akron 7, Ohio *52A-2*
Smith, Earl Louis, 1235 Lander Road, Mayfield Heights, Cleveland 24, Ohio *7M-4*
Smith, Edward J., 114 Chadduck Avenue, Buffalo 7, New York *49A-1*
Smith, Edward L., Jr., 438 North Bottom Road, Berea, Ohio *7M-4*
Smith, Eugene B., 6907 Northampton Way, Houston 24, Texas *22A-1*
Smith, Forrest R., 2519 North Sixty-ninth Place, Scottsdale, Arizona *70AF-4*
Smith, Frank E., Jr., c/o Institute of Modern Management, Incorporated, 1115 South Fourth Street, Louisville, Kentucky *18A-1*
Smith, Frederick S., 1310 Thirtieth Street, N.E., Canton 4, Ohio *19M-3*
Smith, Gerald D., 121 Douglas Drive, Sunset, Utah *50A-2*
Smith, George A., The Yale and Towne Manufacturing Company, 11000 Roosevelt Boulevard, Philadelphia 15, Pennsylvania *31M-4*
Smith, George H., 1944 West Second Avenue, Gary, Indiana *53A-1*
Smith, George R., 2206 South Normandie Avenue, Los Angeles, California *23A-3*
Smith, Gerard L., 42 Glenn Drive, North Wilbraham, Massachusetts *94M-4*
Smith, Harold L., R.R. 2, Auburn Road, Ft. Wayne, Indiana *34A-1*
Smith, Henry G., Jr., 380 Lofton Road, Atlanta 9, Georgia *6A-2*
Smith, Henry G., III, 919 Alfred Street, N.E., Aiken, South Carolina *0A-1*
Smith, Herbert A., Greensboro Finishing Plant, Burlington Industries, Incorporated, Greensboro, North Carolina *21A-2*
Smith, Homer C., 21 Ritlenhouse Road, Broomall, Pennsylvania *31A-2*
Smith, Howard B., 101 Flint Street, Layton, Utah *50A-2*
Smith, Ian Downie, Wheeler Avenue, Fayetteville, New York *3A-1*
Smith, Ira M., 838 Collins Street, Toledo 10, Ohio *36A-4*
Smith, J. Sheppard, 1345 Nashua Drive, Florissant, Missouri *16A-2*
Smith, Jack Vernon, 739 North Ash, Escondido, California *29A-1*
Smith, Jesse Shaffer, 7252 Bentley, Clarendon Hills, Illinois *25M-4*
Smith, John H., 6139 Buena Vista, Mission, Kansas *92A-2*
Smith, John L., Jr., 3007 Thirty-first Street, Lubbock, Texas *0A-1*
Smith, Keith V., 5824 Del Trigo Lane, Concord, California *12A-2*
Smith, Lawrence H., 2060 South Gilpin Street, Denver 10, Colorado *32A-1*
Smith, Lawrence L., 326 North Clark Street, Olean, New York *0A-1*
Smith, Leland K., 2521 Washington Lane, Davenport, Iowa *46A-2*
Smith, Leonard A., Industrial Engineer, Western Union Telegraph Company, 60 Hudson Street, New York 13, New York *5M-4*
Smith, Leonard J., 500 South Ruston Avenue, Evansville 14, Indiana *88M-4*
Smith, Maurice S., Western Electric Company, Incorporated, Graham-Hopedale Road, Burlington, North Carolina *66A-1*
Smith, Morris, Armco Steel Corporation, Middletown Works, Crawford Street, Middletown, Ohio *8M-4*
Smith, Neil, 19 Glenholme Avenue, Toronto 10, Ontario, Canada *87A-1*
Smith, Norman A., 3203 Moon Street, N.E., Albuquerque, New Mexico *59A-1*
Smith, P. Hilton, 307 Overbrook Road, Birmingham 9, Alabama *9M-4*
Smith, Raymond L., 17164 Doublegrove Street, La Puente, California *78M-4*
Smith, Richard B., Bearings Company of America Division, Harrisburg Avenue, Lancaster, Pennsylvania *71A-2*
Smith, Richard L., Hope's Windows Incorporated, 84 Hopkins Avenue, Jamestown, New York *0M-3*
Smith, Robert B., 2706 Oakwood Avenue, N.W., Huntsville, Alabama *69M-4*

Smith, Robert H., Chrysler Engineering, 12800 Oakland Avenue, Highland Park 3, Michigan *47A-2*
Smith, Robert J., 15 Pyrex Street, Corning, New York *48A-3*
Smith, Robert M., Sprout-Waldron and Company, Incorporated, Muncy, Pennsylvania *89M-3*
Smith, Robert P., 444 Willow View Drive, Akron 19, Ohio *52A-2*
Smith, Robert R., 14 Edgewood Road, Hartsdale, New York *5A-2*
Smith, Robert V., P.O. Box 334, Old Fort, North Carolina *83M-4*
Smith, Roger L., Virginia Polytechnic Institute, Department of Industrial Engineering, Blacksburg, Virginia *81M-3*
Smith, Ross, 15 Dwight Road, Burlingame, California *12M-4*
Smith, S. E., Jr., 8820 Flora, Kansas City 10, Missouri *92M-4*
Smith, Spencer B., 35 Claflin Road, Brookline 46, Massachusetts *30A-4*
Smith, Sidney A., 63 Athlone Road, Toronto, Ontario, Canada *87M-3*
Smith, Sidney S., 517 Castle Street, Geneva, New York *30A-2*
Smith, Sim J., Jr., 1101 Oriole Avenue, Miami Springs, Florida *40A-1*
Smith, Thomas H., 1022 Bayfield, Huntsville, Alabama *69M-4*
Smith, Thomas J., The Thomas Smith Company, P.O. Box 6312, Jacksonville 5, Florida *27M-4*
Smith, Vincent R., Manager of Industrial Engineering, Thompson Ramo Wooldridge, Incorporated, 1400 North Cameron Street, Harrisburg, Pennsylvania *95M-4*
Smith, Wade W., Industrial Engineer, Cummins Engine Company, 1000 Fifth, Columbus, Indiana *65AF-4*
Smith, Wayland P., 672 Spartan Avenue, East Lansing, Michigan *0M-3*
Smith, William A., Jr., 320 Willow Road, Hellertown, Pennsylvania *77A-2*
Smith, William A., 217 West Adams Avenue, Borger, Texas *0A-1*
Smith, William C., 189 Long Hill Street, East Hartford, Connecticut *75A-2*
Smith, William L., 4502 Dignam Street, Jacksonville, Florida *27A-2*
Smith, William L., P.O. Box 370, Daingerfield, Texas *60M-4*
Smith, William P., 505 West Henry Avenue, Tampa, Florida *91A-2*
Smith, Wilma A., 3154 North West Twelfth Street, Gainesville, Florida *27A-2*
Smoyer, Thomas E., 928 North Thirtieth Street, Allentown, Pennsylvania *77M-4*
Smyly, William E., 12-A Murrah Apartments, Union, South Carolina *0A-1*
Smyth, Gail B., 2642 El Segundo Drive, Rancho Cordova, California *43M-4*
Smyth, L. C., 4248 Englewood, Wichita 10, Kansas *56A-2*
Smythe, Vernon C., 309 Little John Drive, Baton Rouge, Louisiana *41A-1*
Snakenberg, Ted R., Deere and Company, 3300 River Drive, Moline, Illinois *46M-4*
Sneed, Bill H., 1609½ Edgewood Circle, Chattanooga 5, Tennessee *54A-2*
Snell, Dean, 3409 Club Drive 2, Los Angeles 64, California *23M-4*
Snider, Melford D., 1001 Overton Avenue, Tarrant 7, Alabama *9A-2*
Snidero, Mirco P., 6003 Twenty-third Place, S.E., Washington 21, District of Columbia *14A-2*
Snodgrass, Laurence E., 1132 Monroe Street, S.E., Albuquerque, New Mexico *59M-3*
Snoke, Harlan J., 3332 Twenty-sixth Street, Rock Island, Illinois *46M-4*
Snow, Edward L., 3780 Bridgeview, Cleveland 21, Ohio *7A-4*
Snow, F. A., 431 Brookfield Avenue, Youngstown 12, Ohio *24M-3*
Snyder, Earl E., 175 East Deshler, Columbus 6, Ohio *1A-2*
Snyder, Glenford, 8 Marian Avenue, Poughkeepsie, New York *76A-2*
Snyder, Harold C., P.O. Box 515, Troup, Texas *60M-4*
Snyder, Lester W., Jr., Department of Mechanical Engineering, South Dakota School of Mines, Rapid City, South Dakota *0M-3*
Snyder, Robert J., Stevenson Jordan and Harrison, Incorporated, 21 Main Street, Stonington, Connecticut *0M-3*
Snyder, Theodore, 315 Stonecrest Drive, Dewitt 14, New York *13M-4*
Sockolov, Morris L., Industrial Engineer, Levi Strauss and Company, 98 Battery Street, San Francisco, California *12A-2*
Soderquist, Walter, 95 Closter Dock Road, Closter, New Jersey *61A-2*
Sofleiss, Wallace W., Resident Engineer, Middle Department, Association of Fire Underwriters, Telegraph Building, 216 Locust Street, Harrisburg, Pennsylvania *95M-4*
Sofios, Peter T., Paper Package Company, 1036 North Capitol Avenue, Indianapolis 6, Indiana *65A-2*
Sokhi, K. S., Industrial Engineering Department, TISCO, Jamshedpur-1, India *4M-S*
Solberg, Robert B., 23445 Twenty-seventh Avenue, South, Kent, Washington *20M-4*
Soldo, Nicholas L., 461 Van Rensselaer Road, Utica, New York *85A-2*
Solley, Robert F., Finley Island, Decatur, Alabama *69A-2*
Sollie, James J., Box 227, Ozark, Alabama *0M-3*
Soloman, Jack, 2559 North Muscatel, South San Gabriel, California *23A-1*
Solomon, James D., Jr., 3144 Celeste Way, Salt Lake City, Utah *50AF-4*
Sombat, Louis M., 3790 Meadowbrook Boulevard, University Heights 18, Ohio *7A-2*
Somers, Paul, R.D. 1, Glen Moore, Pennsylvania *71M-4*
Somerville, R. K., Director of Management Service, George A. Touche and Company, 3 London Wall Building, London E.C.2, England *0M-3*
Somerville, Robert W., 47-26 Two Hundred Fifteenth Street, Bayside 61, New York *86A-2*
Sommers, Roy A., 2321 Ardmore Terrace, Apartment D, Winston-Salem, North Carolina *21M-4*
Sonafrank, Robert W., 120 West Washington, Galveston, Indiana *35AF-4*
Sondov, Herman, 2780 University Avenue, Bronx 68, New York *5A-2*
Songailo, Mitchel J., 63 Second Street, Medford 55, Massachusetts *30A-2*
Sonnenberg, LaVerne G., 201 North Willow Street, Kent, Ohio *0A-1*
Sonnendecker, John P., 1101 Bay Road, Webster, New York *44A-2*
Sonntag, George J., 142 Leeds Street, Worcester 6, Massachusetts *68A-2*
Sonntag, Leonard A., 288 East Washington Avenue, Washington, New Jersey *77A-2*
Sons, V. Clarke, 233 Oneida Avenue, N.W., Canton 8, Ohio *19M-3*
Soo, Harry Y., 653 Wyllie, Honolulu, Hawaii *0A-1*
Soper, Robert O., J. G. Ott Packagings, Incorporated, Selinsgrove, Pennsylvania *89A-2*
Sorel, Arthur, 17819 Roseville Boulevard, Roseville, Michigan *47M-4*
Sorensen, Dale A., 2438 South Main Street, Winston-Salem, North Carolina *21A-2*
Sorensen, Dean E., 2020 Continental Illinois Bank Building, 231 South LaSalle Street, Chicago 4, Illinois *25M-4*
Sorensen, L. R., 860 Newell Road, Palo Alto, California *37A-1*
Sorensen, Richard C., 76 Prospect Street, Melrose 76, Massachusetts *30M-4*
Sorrells, Thomas W., 7226 Casa Loma, Dallas, Texas *10A-1*
Sorrels, Bentie D., Star Route B, Midland, Texas *0A-1*
Sorrow, Melvin W., 2846 Boulevard Drive, N.E., Atlanta 17, Georgia *6A-2*
Soth, Roger M., Hammermill Paper Company, East Lake Road, Erie, Pennsylvania *51M-4*
Sotir, Thomas A., 152 Willis Avenue, Medford, Massachusetts *30A-2*
Soule, Herbert N., Chief Industrial Engineer, Maintenance Directorate, MAAMA, Olmsted Air Force Base, Middletown, Pennsylvania *95M-4*
Soule, Robert W., Sylvania Electric Products, Incorporated, 2825 Mt. Pleasant Street, Burlington, Iowa *0A-1*

Soulier, Paul R., 720 Lakeside South, Apartment 405, Seattle 44, Washington *20A-2*
Southern, Joseph L., 3930 Smiley Road, Hilliards, Ohio *1M-L*
Sova, Emil F., 128 Bell Avenue, Saddle Brook, New Jersey *61A-2*
Sowers, Russell F., Trainee, H.S.P.A. Experiment Station, Honolulu 14, Hawaii *0A-1*
Soyars, James W., 920 East Two Hundred Fiftieth Street, Euclid 32, Ohio *7A-2*
Spagnoletti, Isadore F., 336 Herrick Avenue, Teaneck, New Jersey *5A-2*
Spake, Ned B., Florida Power Corporation, 510 Park Avenue, South, Winter Park, Florida *27A-2*
Spangler, Ned W., 1830 South Fifty-fourth Avenue, Cicero, Illinois *25M-4*
Spanley, John J., 8231 Lake Shore Drive, Gary, Indiana *53A-1*
Spanton, Donald L., 4 Long Island Place, N.W., Atlanta 5, Georgia *6M-4*
Sparkes, Robert W., 91 Dewey Avenue, Fairport, New York *44M-4*
Sparks, Nolen, 8655 Forest Hill Drive, Baton Rouge 8, Louisiana *41A-1*
Spaulding, Lee B., 105 Redbud Lane, Tullahoma, Tennessee *64M-3*
Spaulding, Paul G., Paul G. Spaulding and Associates, H. and R. Building, 107 East Washington Street, Syracuse 2, New York *13M-4*
Spaulding, Paul M., 404 Townsend Street, Midland, Michigan *98M-4*
Speare, Alden, 40 Chamberlain Road, Wethersfield 9, Connecticut *75M-4*
Specht, Clayton E., 21861 Maydale Avenue, Euclid 23, Ohio *7M-4*
Specter, Seymour R., 77-15 One Hundred Thirteenth Street, Forest Hills 75, New York *5A-2*
Speight, E. A., Jr., J. P. Stevens and Company, Incorporated, Box 360, Rockingham, North Carolina *66A-1*
Speir, William B., The Rust Engineering Company, 2109 Fifth Avenue, North, Birmingham 3, Alabama *9M-4*
Spell, Daniel M., Jr., 3662 Brantly Avenue, Brunswick, Georgia *0A-1*
Spencer, Jack J., 819 Hillaire Road, Chestnut Hill, Lancaster, Pennsylvania *71M-4*
Spencer, Keith, Steel Company of Canada, Limited, Parkdale Works, Hamilton, Ontario, Canada *87A-1*
Spencer, Kenneth C., 2830 Ashton Drive, Saginaw, Michigan *98A-2*
Spencer, Norman M., Jr., Special Assignments, Baker Perkins, 1000 Hess, Saginaw, Michigan *98AF-1*
Spencer, William C., P.O. Box 7467, Portland 20, Oregon *67M-3*
Sperber, Karl P., 3851 San Marcos Avenue, Riverside, California *78A-2*
Sperling, J. A., 29 Fieldstone Drive, Hartsdale, New York *5A-2*
Spess, Steve, Crawford Addition, Bedford, Indiana *0A-1*
Spewachek, Erwin G., 1842 North Thirty-first, Milwaukee 8, Wisconsin *45M-4*
Spielman, Lester, 1710 Broadway, New York 19, New York *5A-2*
Spilotro, Joseph A., 1943 North Eighteenth Avenue, Melrose Park, Illinois *25A-1*
Spirakis, James, 1446 Patio Drive, Campbell, California *37A-1*
Spires, William H., 421 Healy, North Little Rock, Arkansas *84A-1*
Spitzhoff, Henry W., Robert Heller and Associates, Incorporated, 1568 Union Commerce Building, Cleveland 14, Ohio *7M-4*
Splawn, James L., 220 Memorial Drive, S.W., Decatur, Alabama *69A-2*
Spofford, George E., 329 Woodley Road, Savannah, Georgia *26A-1*
Spohn, John T., 5221 East One Hundred Thirty-second Street, Garfield Heights, Ohio *7A-2*
Sponder, Stephen B., c/o Baker Brothers, Incorporated, 1000 Post Road, Toledo 10, Ohio *36M-4*
Spore, Regis B., 5006 Ash Road, Cleveland 31, Ohio *7A-4*
Spray, Charles F., Jr., 116 Thirty-seventh Street, S.W., Barberton, Ohio *52A-2*
Sprinkle, Charles E., Route 3, Powell, Tennessee *11A-2*
Sproat, John W., 2394 Woodstock Road, Columbus, Ohio *1M-4*
Spung, James L., 1290 Evaline Drive, Columbus 24, Ohio *1A-2*
Spurgeon, William R., 4428 Colfax Place, Seattle 8, Washington *20A-2*
Squair, Donald A., 138 Summit Drive, York, Pennsylvania *72A-2*
Srbich, Alexander L., University of Minnesota (Mech. Dept. Ind. D.), Minneapolis 14, Minnesota *38A-2*
Stabile, Anthony, 2319 West One Hundred Seventeenth Street, Inglewood 4, California *23A-1*
Stack, Hugh J., 3010 Clydedale Drive, Dallas 20, Texas *10M-3*
Stacy, Stanley L., Jr., 106 Kimberly Road, Somerville, New Jersey *61A-2*
Staeck, James F., 615 South Fifteenth Avenue, Yakima, Washington *0M-3*
Stahl, Raymond F., 9735 Old CCC Highway, Westerville, Ohio *1A-4*
Stainback, Raiford H., Jr., P.O. Box 306, Talpa, Texas *0A-1*
Staines, Richard O., Box 1979, Tulsa 1, Oklahoma *15A-3*
Stalcup, Edwin N., 217 Winchester, Glendale, California *23M-4*
Staley, James F., 325 Lincoln Street, Bangor, Maine *63A-1*
Staley, Roy, 308 Lee Street, Seattle 9, Washington *20AF-3*
Stalker, James I., Thompson Products, Incorporated, 34201 Van Dyke Avenue, Warren, Michigan *47M-4*
Stallard, Arthur Kenneth, 13 Allenby Avenue, Rexdale, Etobicoke, Ontario, Canada *87M-3*
Stamm, James, Sr., 2678 Valvedere Drive, N.E., Atlanta 19, Georgia *6M-4*
Stamm, James E., 73 Walnut Street, Salem, West Virginia *0A-1*
Stamper, Hubert C., 705 West Twenty-fourth, Pine Bluff, Arkansas *84A-1*
Stanas, Louis H., 143 High Street, Foxboro, Massachusetts *30A-2*
Stanberry, John L., Industrial Engineer, Tinker Air Force Base, 501 North Cherokee, Claremore, Oklahoma *57A-2*
Standard, John C., 805 Lazy Lane, Bryan, Texas *0A-1*
Stanich, Joe, 431 School Street, Warren, Ohio *24A-1*
Stanley, Clifford L., 219 Countryside Drive, Irving, Texas *10A-1*
Stanley, Goebel E., 4234 Howard Street, Western Springs, Illinois *25M-4*
Stanley, James B., Apartment 15, 2800 Pennsylvania Avenue, Boulder, Colorado *32A-1*
Stanley, Robert E., 2529 Knox Street, N.E., Atlanta 17, Georgia *6A-2*
Stansbury, John V., 7876 Truxton Avenue, Los Angeles 45, California *23M-4*
Stansell, M. G., 20 B. Westwood Heights, Macon, Georgia *55A-1*
Stansell, William J., Jr., 100 North Swarthmore Avenue, Apartment C, Ridley Park, Pennsylvania *31A-2*
Stanton, Wyllys G., Sr., Box 1997, University, Alabama *0F-0*
Staples, Robert R., 2443 South Culpepper Street, Arlington 6, Virginia *14A-2*
Stapleton, Patrick G., 16 Lenox Avenue, Maywood, New Jersey *61M-4*
Stark, John W., 3122 Fifty-fifth Street, San Diego 5, California *29A-1*
Stark, Joseph A., Mack Manufacturing, Allentown, Pennsylvania *77A-4*
Stark, Ronald Lloyd, Massey-Ferguson, Limited, 915 King Way, Toronto 3, Ontario, Canada *87M-3*
Stark, W. L., Sr., Planning Form., Ethyl Corporation, P.O. Box 341, Baton Rouge 1, Louisiana *41AF-3*
Starshuk, Stephen S., 82 Stinson Street, Hamilton, Ontario, Canada *87A-1*
Staszak, Leonard A., P.O. Box 262, Inglewood, California *23A-3*
Staton, Donnell J., 605 West Poplar, Shawnee, Oklahoma *57A-2*
Staub, Russell, Industrial Electric Company, 3 South Fifth Street, Nashville 6, Tennessee *73AF-3*
Stauber, Walter J., 125 Euclid Avenue, Massapequa, New York *86M-4*
Stauffer, John L., 3103 Rolling Wood, Tyler, Texas *60A-2*
Staunton, Robert E., 1821 Winnetka Avenue, N., Minneapolis, Minnesota *38A-2*
Stearn, Robert P., 459 Essex Street, Weymouth, Massachusetts *30A-2*

Stearns, Stuart G., Merck and Company, Incorporated, Rahway, New Jersey *61A-4*
Stebbins, Ernest F., 14 Carron Lane, Oxford, Massachusetts *68A-2*
Steckley, Kurt D., New Street, Branchville, New Jersey *61A-2*
Steed, George J., 682 Arcadia Road, Ridgewood, New Jersey *61A-2*
Steele, Carl A., 200 Dale Drive, Silver Spring, Maryland *14A-2*
Steele, Harold M., 3206 West Seventy-sixth Street, Los Angeles 43, California *23M-4*
Steen, M. V., 89 Kellogg Way, Santa Clara, California *37A-1*
Steffan, Leonard D., R.R. 1, Sidney, Montana *0A-1*
Steffens, Oscar C., 10032 Carolynne Drive, St. Louis 23, Missouri *16A-2*
Stegall, Benjamin I., Jr., 3419 Club Drive, Apartment 7, Los Angeles 64, California *23A-3*
Steger, John R., 7073 Olive Street, Highland, California *78A-2*
Stein, Adolph L., 715 Imlay, San Antonio, Texas *39AF-4*
Stein, Harlan M., 9015 Debra Avenue, Sepulveda, California *23A-1*
Steiner, James, 241 Heywood Avenue, Orange, New Jersey *61A-2*
Steiner, Stanley, 15735 Norwich Avenue, Livonia, Michigan *47M-4*
Steingart, Frank, Jr., Dartmoore Road, Mentor, Ohio *7A-4*
Steinhardt, Frank J., Tool Engineering, Group Leader, EIMCO Corporation, P.O. Box 300, Salt Lake City, Utah *50AF-4*
Steinwedell, William E., 5349 Aura Avenue, Tarzana, California *23A-1*
Stellpflug, John R., 5614 Circle Hill Drive, N.W., Canton 9, Ohio *19M-3*
Stelmach, James R., R. R. Donnelley and Sons Company, 350 East Twenty-second Street, Chicago 16, Illinois *25A-1*
Stelzer, Harold L., 69 Corona Road, Rochester 15, New York *44A-2*
Stember, Jerome A., 909 East Fifth Street, Brooklyn 30, New York *5A-2*
Stenvall, John T., 4051 La Rica Avenue, Apartment 15, Baldwin Park, California *23A-1*
Stephan, Stanley S., Armstrong Cork Company, Liberty Street, Lancaster, Pennsylvania *71M-4*
Stephens, Bernard W., 18 Thompson Avenue, South Fort Mitchell, Kentucky *8A-2*
Stephens, James B., 1412 Buena Vista, San Clemente, California *23A-1*
Stephens, John L., 699 Riverview Drive, Florence, Alabama *69A-2*
Stephens, Sammie F., 411 North Ashley Street, Valdosta, Georgia *27A-2*
Stephenson, Albert G., 3913 Upper Mount Vernon Road, Evansville, Indiana *88A-2*
Stephenson, Charles F., 225 East Market Street, York, Pennsylvania *72M-4*
Stephenson, James D., Tampax Incorporated, Bridge and Springfield Streets, Palmer, Massachusetts *94AF-4*
Stephenson, John R., 259 Montrose Avenue, N.W., Canton 8, Ohio *19A-1*
Stephenson, Samuel S., Jr., 263 West End Avenue, New York 23, New York *5M-4*
Stephenson, William J., Libbey-Owens-Ford Glass Company, Plant No. 6, Rossford, Ohio *36A-2*
Sterle, Frank J., 3617 Regent Lane, Wantagh, Long Island, New York, c/o Levittown P.O., New York *86A-2*
Sterling, Merritt J., Cynwyd Court, Apartment 2D, Bala-Cynwyd, Pennsylvania *31M-4*
Sterling, Sheldon R., 501 University Avenue, Endwell, New York *96M-3*
Stern, Alvin J., 25 Dock Lane, Wantagh, New York *5M-4*
Stern, Walter S., 15 Stauber Drive, Plainview, Long Island, New York *86A-2*
Sternberger, Harold, 229 Princess Street, Hicksville, New York *86A-2*
Sternfels, Lewis B., 924 Twenty-fifth Street, N.W., Apartment 417, Washington 7, District of Columbia *14A-2*
Stetson, Robert C., 3431 Kirk Road, Youngstown 11, Ohio *24A-1*
Steudel, Max, 217 Summer Street, Buffalo, New York *49M-3*
Steurer, George E., Bendix Computer Division, 5630 Arbor Vitae Street, Los Angeles 45, California *23M-4*
Stevens, Carl A., 1932 North Boston Avenue, Tulsa 6, Oklahoma *15M-3*
Stevens, Gary D., 1065 South Hatcher Street, La Puente, California *12A-2*
Stevens, Harry A., Jr., 9515 Larchwood Drive, Dallas 18, Texas *10A-3*
Stevens, Irvin W., Jr., 387 "L" Street, Salt Lake City 3, Utah *50A-2*
Stevens, John A., 187 Barmont Drive, Rochester 13, New York *44A-2*
Stevens, John H., 7518 Locust Avenue, Gary, Indiana *53M-3*
Stevens, Lyell B., 4323 North Ritter Avenue, Indianapolis 26, Indiana *65M-4*
Stevens, William L., 4803 Franklin Street, Bethesda, Maryland *14M-4*
Stevenson, Frank B., Lufkin Foundry and Machine Company, Box 58, Lufkin, Texas *0M-3*
Stevenson, John, Food Machinery and Chemical Corporation, 103 East Maple Street, Hoopeston, Illinois *80M-4*
Stevenson, Robert B., Industrial Engineer, Purity Stores, Limited, 1645 Rollins Road, Burlingame, California *37A-1*
Steward, George S., 1631 West Broad Street, Bethlehem, Pennsylvania *77A-2*
Stewart, David C., 15 Rice Spring Lane, Wayland, Massachusetts *30A-4*
Stewart, Donald J., 942 North Nelson Road, Columbus 9, Ohio *1AF-4*
Stewart, Frank William, 1565 Twenty-third Street, Ogden, Utah *50A-4*
Stewart, Gerald R., 3501 West Eighty-second Place, Chicago 29, Illinois *25M-4*
Stewart, John S., North Pickering Street, Brookville, Pennsylvania *0M-3*
Stewart, Raymond M., Methods and Equipment Research Engineer, Climax Molybdenum Company, Climax, Colorado *32A-1*
Stewart, Walter E., Route 1, Box 161, Phalanx, Ohio *24M-3*
Stiarwalt, Dan W., 15763 Northeast First Street, Bellevue, Washington *20A-2*
Stice, Archie C., 4906 Harding, Midland, Michigan *98M-4*
Stidger, Perry W., Jr., 1132 Crowley Avenue, Santa Clara, California *37A-1*
Stiebing, Kurt W., 952 Croyden Drive, Dayton 20, Ohio *2A-2*
Stilian, G. N., 620 Pelham Road, New Rochelle, New York *5A-4*
Stilson, Donald E., 6206 Heron, Houston 17, Texas *22M-4*
Stine, James M., 3412 Trindle Road, Camp Hill, Pennsylvania *95A-2*
Stine, John H., 1117 West Twenty-eighth, Erie, Pennsylvania *51A-2*
Stine, Joseph P., 5218 Haverill Drive, Orlando, Florida *27A-2*
Stine, Robert H., P.O. Box 2513, Orlando, Florida *27A-2*
Stirrup, John T., Methods and Time Study Engineer, Duro-Test Corporation, 2321 Hudson Boulevard, North Bergen, New Jersey *61A-2*
Stivers, D. Alwyn, 1076 Wilson Street, St. Paul 6, Minnesota *38A-2*
Stockton, Franklin B., Great Lakes Steel Corporation, Ecorse, Detroit 29, Michigan *47M-4*
Stockton, John E., 4701 Conlin, Evansville 15, Indiana *88M-4*
Stockton, John F., 510 East-South Second Street, Kernes, Texas *0A-1*
Stockton, Warren, 117 South Patrick, Dublin, Texas *0A-1*
Stockwell, John H., 109 Ohio Street, Travis Air Force Base, California *0A-1*
Stockwell, Robert F., Special Industrial Engineer Fac., General Electric Company, Box 196, Flight Propulsion Laboratory Department, Evendale 15, Ohio *8AF-4*
Stoddard, Albert A., 2700 Lullington, Winston-Salem, North Carolina *21A-2*
Stodghill, James A., 800 East Pine Street, Orlando, Florida *27A-2*
Stoffel, Dan J., Marion Power Shovel Company, Marion, Ohio *0AF-3*
Stogryn, Walter, Hilltop Drive, Madison, Connecticut *82A-2*

Stokes, Clifford G., 207 Church Road, Harold Wood, Romford, Essex, England *0M-3*

Stolberg, William G., Manager of Manufacturing, General Electric X-Ray, 4855 West Electric, Milwaukee, Wisconsin *45M-4*

Stolzenberg, Arthur A., 185 South New Road, Hamden, Connecticut *97M-4*

Stone, Albert B., 15235 East LaCalmea Drive, Friendly Hills, Whittier, California *23M-4*

Stone, Fred D., 174 Sheridan Road, Winnetka, Illinois *25A-1*

Stone, Gary G., 1112 Eighth Street, Apartment D, Albany 10, California *12A-2*

Stone, George C., Union Carbide Corporation, 30 East Forty-second Street, New York 17, New York *5M-4*

Stone, James E., 1665 South Tennyson, Denver 19, Colorado *32A-3*

Stone, John F., 1105 Stanhope Drive, Huntsville, Alabama *69M-4*

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Timmermeier, Newell D., 1032 Danforth, Alton, Illinois *16AF-4*
Timmins, Harold C., 2423 Adrian Street, Harrisburg, Pennsylvania *71A-2*
Timmons, Robert M., 3715 Rollingwood Drive, Chattanooga 11, Tennessee *54A-2*
Timms, G. W., 12 Arbetter Drive, Framingham, Massachusetts *30A-2*
Tims, George B., Jr., Department of Industrial Engineering, Lamar State College of Technology, Beaumont, Texas *0M-3*
Tin, Maung M., c/o U Shwe Thwin, D.C.'s Office, Meiktila, Burma *0A-1*
Tingwald, Val Gene, Western Electric Company, Incorporated, Box 1400, Peony Park Station, Omaha 14, Nebraska *90A-2*
Tinker, Kemper M., 7831 Burnham Avenue, Chicago 49, Illinois *25M-4*
Tintera, George B., 3224 East Thirty-ninth Street, Apartment 523, Indianapolis 5, Indiana *65A-2*
Tippitt, Frank W., Box 414, Southern Methodist University, Dallas 22, Texas *10A-1*
Tippy, James V., Star Route, Box 410, Lytle Creek, California *78A-2*

Tipton, Emmett J., Medart Manufacturing Company, 3535 DeKalb, St. Louis 18, Missouri *16A-2*
Titler, F. J., 3475 Polley Avenue, Columbus 21, Ohio *1F-0*
Tittel, Richard P., 137 Center Avenue, Chatham, New Jersey *61A-2*
Tivald, Julius G., 128 West Adams, Paulsboro, New Jersey *31A-2*
Tobin, Margaret A., 616 Highland Avenue, Toledo 10, Ohio *36A-2*
Todd, Forrest Randolph, 16 Purchase Street, Newburyport, Massachusetts *30M-4*
Todd, Thomas F., 2406 Anderson Road, Falls Church, Virginia *14A-2*
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Tolley, Joseph C., 408 Orchard Street, Bridgeport, West Virginia *0A-1*
Tolley, P. R., 177 Sheffield Road, Cincinnati 15, Ohio *8M-4*
Tolstrup, Richard W., General Electric Company, 1 River Road, Building #81-2, Schenectady 5, New York *0M-3*
Tombari, Aldo L., 5945 Claystone, Sylvania, Ohio *36M-4*
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Tovar, Robert J., 80 Strong Street, Bronx 68, New York *5M-4*
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Tracey, Frank J., 2712 South Vrain Street, Denver 19, Colorado *32A-1*
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Transeau, Leon W., 2201 Burlington Avenue, Riverside, New Jersey *31A-2*
Trau, Frank G., Jr., St. Louis-San Francisco Railway Company, 543 East Commercial Street, Springfield 2, Missouri *16A-2*
Traut, Ralph, 441B North Thirty-ninth, Milwaukee, Wisconsin *45AF-4*
Trautz, William B., 27 Oakmont Lane, Signal Mountain, Tennessee *54M-4*
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Trent, Fred A., 1940 Carolina Avenue, Port Arthur, Texas *0A-1*
Trent, William L., Via Dei Franzone 6/15, Genova, Italy *25A-3*
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Treskov, Alexander, 1084 Willmohr, Brooklyn 12, New York *5A-2*
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Triplett, C. T., Industrial Engineer, Chrysler-Kokomo Plant, Kokomo, Indiana *35A-2*
Tritt, Edgar H., 4995 Stacy Street, Oakland 5, California *12M-4*
Trobaugh, Jimmy L., Salem Road, Milan, Tennessee *0A-1*
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Trone, Curvin J., Jr., 894 Ogden Avenue, Benton Harbor, Michigan *0A-1*
Trost, Frederick E., 6935 Midwood, Berkeley 21, Missouri *16AF-4*
Trost, Vernon F., 5317 South Caroline, Western Springs, Illinois *25M-4*
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Truluck, Cecil M., Jr., USS SELLSTROM (DER 255), c/o Fleet Post Office, New York, New York *0A-1*
Trumbo, Robert H., 13115 Chestnut Street, Wyandotte, Michigan *47M-4*
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Tryon, Walter W., Box 1093, Rio Vista, California *12M-4*
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Tuck, Thomas K., 541 Poplar Street, Canal Fulton, Ohio *52A-2*
Tucker, Arthur L., 65 Mills Lane, Bloomfield, Connecticut *75M-4*
Tucker, Augustine W., Jr., Ecusta Paper Division, Box 200, Olin Mathieson Chemical Corporation, Pisgah Forest, North Carolina *83AF-4*
Tucker, Charles R., 11224 West Sixty-seventh Terrace, Shawnee, Kansas *92AF-4*
Tucker, George E., 2112 Dunhill Drive, Raleigh, North Carolina *66M-3*
Tucker, John L., 274 East Aliso Street, Pomona, California *23M-4*
Tucker, Leo E., 1803 Elder Drive, Arlington, Texas *10M-3*
Tucker, R. A., 15 Poplar, Rome, Georgia *93A-2*
Tucker, Robert J., 6 Bell Drive, R.D. 4, Cortland, New York *13M-4*
Tucker, Thomas Elwood, P.O. Box 295, Thunderbolt, Georgia *26M-3*
Tudor, Melvin, 63-50 Wetherole Street, Rego Park 74, New York *86M-4*
Tuey, Richard C., 117 Thirty-second South, Seattle 44, Washington *20AF-3*
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Tullar, Frederick E., 23 Brook Street, Manchester, Massachusetts *30A-2*

Tunick, Samuel Myron, 5 Manor Drive, Newark 6, New Jersey *61M-4*
Turk, Robert H., 916 Annabelle Drive, Toledo 12, Ohio *36M-4*
Turkes, Walter R., 149 Lawrence Avenue, Homestead Park, Pennsylvania *3M-3*
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Turner, Ira B., Jr., 2845 O'Berry Street, Raleigh, North Carolina *66A-1*
Turner, James R., Jr., 2860 Highlands Boulevard, Spring Valley, California *29A-1*
Turner, Tom W., 1216 Glen Laura Road, Jacksonville 5, Florida *27A-2*
Turney, Joe A., 2215 South Ozark, Joplin, Missouri *0A-1*
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Tuzi, Louis A., 16602 Grovewood Avenue, Apartment 4, Cleveland 10, Ohio *7M-4*
Twaddell, William E., 78 Haven Avenue, New York 32, New York *5A-2*
Twedt, Patrick A., 390 West Fifth, Britt, Iowa *0A-1*
Tyler, Charles C., 1810 West Front Street, Burlington, North Carolina *66M-3*
Tyler, John, 1645 South Carson, Apartment 1, Tulsa, Oklahoma *15A-1*
Tyler, Truett, Convair, Department 8-1, Building 33, 3302 Pacific Highway, San Diego, California *29M-3*
Tyson, Harry B., Jr., 3063 North Forty-second Drive, Phoenix, Arizona *70A-2*
Tyson, Herbert I., 76-12 Thirty-fifth Avenue, Jackson Heights 72, New York *5A-2*

Uber, Daniel W., 3521 Edison, Trenton, Michigan *47A-2*
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Ujlaky, Albert, 1506 West Columbia Avenue, Davenport, Iowa *46M-4*
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Ullman, Sidney G., 3008 East Cheltenham Place, Chicago 49, Illinois *25A-1*
Ulman, Theodore B., 68 Breer Circle, Brockton, Massachusetts *30A-2*
Umanetz, Alex, Jr., 42 Potters Lane, Great Neck, New York *5A-4*
Umbach, William J., 11 Warren Place, Waldwick, New Jersey *61M-4*
Underwood, Gerald T., 5429 Sixth Avenue, Moline, Illinois *46M-4*
Underwood, James Allen, Box 741, Wilmington 99, Delaware *100A-3*
Unferth, William, International Harvester Company, 1100 Third Street, East Moline, Illinois *46M-4*
Unger, Donald J., 1533 Granger, Redwood City, California *37M-4*
Unger, Martin S., Jr., 2801 Northampton Street, Easton, Pennsylvania *77A-2*
Unninayar, M. N., N.P.C., 38 Golf Links, New Delhi, India *4A-8*
Unser, Henry F., Jr., 517 South Poplar, Hartford City, Indiana *35A-2*
Unser, Raymond M., 706 Cain Street, Hampton, South Carolina *0M-3*
Upchurch, Edwin B., 1576 Fama Drive, N.E., Atlanta 6, Georgia *6A-2*
Upchurch, Robert E., 1116 South West One Hundred Thirty-nine, Seattle 66, Washington *20A-2*
Updegraff, Ralph W., 4424 Seventh, S.W., Canton 10, Ohio *19M-3*
Updegraff, W. Robert, 15 Vernon Drive, Buffalo 25, New York *49M-3*
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Uranich, Frank A., 916 Putnam Street, Peru, Illinois *80A-2*
Urban, Robert, 934 East Eighteenth Street, Chester, Pennsylvania *31A-2*
Urbanski, Edward F., 1538 Elkins Avenue, Abington, Pennsylvania *31M-4*
Ussery, Milton E., Lakeview Road, Fairmont, North Carolina *0A-1*
Utley, Robert G., 1503 Pennylane, Decatur, Alabama *69A-2*
Utter, James R., 2225 Glenside, Cincinnati 12, Ohio *8M-4*
Utz, Robert L., 6324 Farmar Lane, Floutown, Pennsylvania *31A-4*

Vactor, Howard, 15810 Van Aken, Cleveland 20, Ohio *7A-2*
Vaden, Frank S., III, 501 Angus Street, South, College Station, Texas *0A-1*
Vader, J. Quentin, National Lead Company, TIT Division, Carondelet Station, St. Louis 11, Missouri *16M-4*
Vagnini, Louis T., 1320 Anderson Avenue, Palisade, New Jersey *5A-2*
Vail, Thomas P., 37 South Maple, Warsaw, New Jersey *0A-1*
Vais, James A., 223 Laurel Avenue, Menlo Park, California *37A-4*
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Valenteen, John Vincent, 414 South West End Avenue, Lancaster, Pennsylvania *71M-4*
Valenti, Donald F., 27 Admiral Lane, Hicksville, New York *86M-4*
Valentine, Alfred O., 859 Spruce Street, Pottstown, Pennsylvania *31A-4*
Valentine, Deane B., Colorado Fuel and Iron Company, 361 Delaware Avenue, Buffalo, New York *49M-3*
Valentine, Maurice T., Box 568, Hartselle, Alabama *69A-2*
Valfer, Ernst S., 201 Stonewall Road, Berkeley 5, California *12M-4*
Vallette, William J., CBS Electronics, A Division of Columbia Broadcasting System, Incorporated, Danvers, Massachusetts *30M-4*
Van Bergen, Hans M., 387 Brixton Avenue, St. Lambert, Montreal 23, Quebec, Canada *0A-1*
Van Dalsem, Dale W., 729 Waverley Street, Palo Alto, California *37A-1*
Vandament, Omar K., Virco Manufacturing Corporation, P.O. 911, Highway 65, South, Conway, Arkansas *84A-1*
Van Der Beek, Wilbur B., Jr., United States Rubber International, 1230 Avenue of the Americas, New York 20, New York *61A-2*
Van Der Heyden, J., 892 Bathurst Street, Toronto, Ontario, Canada *87AF-3*
Vandermark, Bernard M., 3420 Cherokee, San Diego 4, California *29A-1*
Vander-Mast, Adrian C., RayBestos-Manhattan, Incorporated, Wabash Division, Darlington Avenue, Crawfordsville, Indiana *35A-2*
VanderMyde, Earl C., 10745 South Morgan Street, Chicago 43, Illinois *25A-3*
van der Poel, A. A., c/o Koeduinweg 5, Aerdenhout, Holland *0AF-3*
Vanderslice, John Willard, Paul Edwards and Associates, First National Bank Building, Pittsburgh, Pennsylvania *3M-3*
VanDusen, Walter F., Jr., Route 1, Box 767, Escondido, California *29M-3*
Van Dyke, C. Elmer, 1115 Thompson Avenue, Liberty, Missouri *92M-4*
Van Eman, Cary J., 603 Edward, LaMarque, Texas *22A-1*
VanEman, E. K., Jr., 5427 East Twenty-fourth Street, Tulsa 14, Oklahoma *15A-3*
Van Etten, H. Paul, 169 Stafford Avenue, North, Waterville, New York *85A-2*
Vange, Howard W., 12717 Twenty-third, N.E., Seattle 55, Washington *20A-2*
Van Harlingen, David E., 3212 Wilmington Avenue, Dayton 29, Ohio *2A-4*
Van Hoesen, Richard C., 2952 Laskey Road, Toledo 13, Ohio *36A-2*
Van Horne, Clive H., Stevenson and Kellogg, Limited, 10 Eglinton Avenue, East, Toronto 12, Ontario, Canada *87M-3*
Van Landingham, William R., 1205 West Washington, Midland, Texas *0A-1*
Van Meter, Richard, 34 Autumn Drive, Rochester 15, New York *44A-2*
Vanni, Mario A., 970 Washington Avenue, Hohokus, New Jersey *61A-2*

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Van Orsow, Martin J., 3814-42 Avenue, S.W., Seattle 16, Washington *20A-2*
Van Osten, George K., 5748 Erdrick Street, Philadelphia 24, Pennsylvania *31M-4*
Van Raalte, Ernest, c/o Robin-Nodwell Manufacturing, Limited, Fiftieth Avenue and First Street, S.W., Calgary, Alberta, Canada *0A-1*
Van Stavern, Alva N., 306 East Euclid Road, Prospect Heights, Illinois *25M-4*
Van Tassel, Carl J., 105 West Fifty-fifth Street, New York 19, New York *5A-2*
VanWagnen, Carl G., 8035 Sixteenth Avenue, N.W., Seattle 7, Washington *20M-4*
Van Zwalenburg, Paul R., P.O. Box 245, Puunene, Maui, Hawaii *0A-1*
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Varner, Siegel S., Jr., 8533 Eleventh Avenue, South, Minneapolis 20, Minnesota *38A-2*
Varnier, Herman E., 6401 Clydewood Avenue, Richmond 24, Virginia *0A-3*
Varnson, Thomas M., 1004 Alexandria Drive, Mayfair S. D., Pensacola, Florida *33A-1*
Varraux, I. A., 711 Shady Avenue, Sharon, Pennsylvania *24M-3*
Vasiliou, George, 622 Dalton Street, Marion, Virginia *0A-1*
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Vaughan, Frank M., 10128 Goodyear Drive, Dallas 29, Texas *10A-1*
Vaughan, Sherman L., 1401 West Hempstead, Pasadena, Texas *22A-3*
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Ventura, George J., Harnischfeger Corporation, Truck Crane Plant, Danforth Road, Escanaba, Michigan *45M-4*
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Verzosa, A. Norbert, 2244 West Farragut, Chicago 25, Illinois *25A-1*
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Vesely, Charles, 2830 Burlawn Parkway, Brookfield 10, Wisconsin *45M-4*
Vesling, Gerald C., Sylvania Electric Products, 12 Second Avenue, Warren, Pennsylvania *51M-4*
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Vester, Lyle A., 1019 Goshen Pike, Milford, Ohio *8M-4*
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Vetter, Robert A., 2734 Clara, Ft. Wayne, Indiana *34A-1*
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Vidal, Louis, 3572 Monroe Street, Gary, Indiana *53A-1*
Vidal, Manuel, 424 Harrison Street, Gary, Indiana *53A-1*
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Vincent, Merlin D., 1815 East Georgia Street, Phoenix, Arizona *70A-2*
Vincent, Robert W., 1203 Arcadia Street, Orlando, Florida *27A-2*
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Vogel, Leo C., 2514 East Pierson Street, Phoenix, Arizona *70A-2*
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Vollmer, Robert G., 553 North Central, Chicago 44, Illinois *25A-1*
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Volyn, Robert P., 78 Berkley Court, Wayne, New Jersey *61AF-4*
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Volz, Marvin D., 13728 Woodlark, Rockville, Maryland *14A-2*
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von Ahlefeldt, Rolf S., 1325 Greenwood Street, Pueblo, Colorado *32M-3*
von Brecht, Forrest G., 6 Forest Ridge, Clayton 5, Missouri *16M-4*
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Voss, Gerald P., 8537 Elmira, Detroit 4, Michigan *47A-2*
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Vought, John H., Liberty Street, Arcade, New York *49A-1*
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Vrbancic, Walland P., 6028 East Eberly Street, Lakewood, California *23A-1*
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Wadsworth, Harrison M., Jr., 4540 West One Hundred Sixty-eighth Street, Cleveland 11, Ohio *7A-4*
Waechter, James M., 329 Schofield Building, Cleveland 15, Ohio *7M-4*
Waeckerle, William S., 3065 Kingsley Drive, Florissant, Missouri *16A-2*
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Wagner, Charles A., Jr., 44 Oak Ridge Drive, East, Brockton, Massachusetts *30M-4*
Wagner, Charles J., 715 South Bennighof Avenue, Evansville 14, Indiana *88A-2*
Wagner, Donald Duane, 408 Solano Drive, N.E., Albuquerque, New Mexico *59A-1*
Wagner, James G., 344 Tenth, Elyria, Ohio *7A-2*
Wagner, John V., 1763 Laurelhurst Drive, Salt Lake City 8, Utah *50A-2*
Wagner, Norman H., Chicopee Manufacturing Company, 26 North Garden Street, Bensenville, Illinois *25AF-3*
Wagner, Paul W., Langford-Clarksburg Road, Eden, New York *49A-1*
Walcutt, Wayne W., Bell Sound Systems, Incorporated, 555 Marion Road, Columbus 7, Ohio *1M-4*
Waldrop, Edwin W., 1711 Shadford Road, Ann Arbor, Michigan *0M-3*
Waldvogel, Robert K., 75 Greenvale Drive, Rochester 18, New York *44M-4*
Walichowski, Edward J., 6145 Chaffin Street, Houston 17, Texas *22A-3*
Walk, Robert F., Industrial Engineer, Rochester Products, Division of GMC, Lexington Avenue, Rochester, New York *44A-2*
Walker, Albert G., 422 East Greenland Avenue, Oconomowoc, Wisconsin *45A-2*
Walker, Clyde C., Acme Steel Company, Riverdale Station, Chicago 27, Illinois *25M-4*
Walker, Donald S., 322 Overbrook Road, New Brunswick, New Jersey *61A-2*
Walker, Ernest H., Granite City Steel Company, Twentieth and Madison, Granite City, Illinois *16A-2*
Walker, Frank E., Jr., 20 Williamson Park Drive, Newport News, Virginia *14A-2*
Walker, Frederick J., 943 West G Street, Ontario, California *78A-2*
Walker, Howard B., 1236 Cross Key Drive, Atlanta 19, Georgia *6A-2*
Walker, Jack R., 1963 Briar Mill Road, N.E., Atlanta 6, Georgia *6A-4*
Walker, Richard, Mead Containers, Incorporated, Delavan Division, P.O. Box 1138, Syracuse 1, New York *13A-2*
Walker, Robert F., 912 Glenroy Road, Philadelphia 28, Pennsylvania *31A-2*
Walker, Robert O., 566 Valley View Drive, Hamilton, Ohio *8M-4*
Walker, Ronald L., 2919 Clearfield Avenue, Akron 14, Ohio *52A-2*
Walker, Thomas K., 1250 Koppers Building, Pittsburgh 19, Pennsylvania *3A-1*
Walker, William E., R.F.D. 1, Box 6, Kingston, New York *76A-2*
Walker, William R., 901 Holmes Street, Salisbury, North Carolina *21A-2*
Wall, Billy Joe, Box 27, Puryear, Tennessee *0A-1*
Wall, Charles R., 2009 Ribault Scenic Drive, Jacksonville 8, Florida *27M-4*
Wall, Gordon A., Johns-Manville Corporation, 22 East Fortieth Street, New York, New York *5M-4*
Wall, Joe Hanson, Cost Control Department, Hudson Pulp and Paper Corporation, Palatka, Florida *27A-2*
Wallace, Charles R., Route Number 3, Clarksville, Tennessee *0A-1*
Wallace, L. W., Top Management Seminar, Ordnance Management, Engineering Training Program, Rock Island Arsenal, Rock Island, Illinois *46F-0*
Wallace, William S., Apartment E-1, Sapphire Manor, Brevard, North Carolina *83A-2*
Wallack, Paul M., 2116 Ventura Drive, Tempe, Arizona *70A-2*
Waller, Douglas S., 648 Sleepy Hollow Road, Falls Church, Virginia *14A-2*
Waller, Frank D., 1063 West Richmond Street, Macon, Georgia *55A-1*
Wallgren, Ronald E., 501 East Thirty-second Street, Apartment 801, Chicago 16, Illinois *25AF-3*
Wallner, Siegfried, Jr., 1104 Woodbine Way, Signal Mountain, Tennessee *54AF-4*
Walls, Robert T., 49 East McClellan Avenue, Livingston, New Jersey *61M-4*
Walmsley, Charles Alfred, Charles A. Walmsley and Associates, 1984 Railway Exchange Building, St. Louis 1, Missouri *16M-4*
Walp, Jack S., 37 Brookline Avenue, Youngstown 4, Ohio *24M-3*
Walser, Vergil H., Registration Office, United States Post Office, 512 Nicollet Avenue, Minneapolis 2, Minnesota *38M-4*
Walsh, Arthur P., 29 Village Drive, King's Village, Saugerties, New York *76M-4*
Walsh, Frederick, 603½ South West Street, Lebanon, Indiana *65M-4*
Walsh, Harry H., Jr., 9810 Larston Drive, Houston 24, Texas *22M-4*
Walsh, Philip A., 341 Canova Lane, Dayton 31, Ohio *2M-4*
Walsweer, J. A., Building #94, United States Coast Guard Reserve Training Center, Yorktown, Virginia *25A-1*
Walter, Donald F., United States Navy, U.S.S. Maury (AGS-16), F.P.O., New York *0A-1*
Walter, Harvey R., Allison Division, GMC, P.O. Box 894, Department 0510, Indianapolis 6, Indiana *65A-2*
Walter, Russell W., R.R. 5, Valparaiso, Indiana *53M-3*
Walter, T. Edgar, Jr., 1816 Thomas Place, Arlington, Texas *10M-3*
Walters, George L., Route 1, Box 737, Pensacola, Florida *33A-1*
Walters, Jack E., 1848-B Claymore Drive, Marietta, Georgia *6A-2*
Walters, William F., Industrial Engineer, Colgate-Palmolive Company, P.O. Box 223, Kansas City 41, Missouri *92M-4*
Walters, William P., 119 West Water, Sidney, Ohio *0A-1*
Walton, Harry B., Jr., 930 Martha Avenue, Lancaster, Pennsylvania *71M-4*
Walton, Richard W., 804 Old Lincoln Highway, Langhorne, Pennsylvania *31M-4*
Walton, William M., Burton Manufacturing Company, Incorporated, P.O. Box 351, Jasper, Alabama *9A-4*
Waltz, Charles H., 57 Garden Terrace, Pittsburgh 21, Pennsylvania *3M-3*
Waltz, Edward G., Eastman Kodak, Kodak Park, Building #2, Rochester 4, New York *44M-4*
Wamser, Richard E., Three Hundred Seventy-eighth Ordnance Company, Camp Irwin, California *78A-2*

Wanner, Richard L., Fox Hill Road, Woodbridge, New Haven 15, Connecticut *97M-4*
Wanninger, George T., 203 Royal Avenue, Ferguson 21, Missouri *16M-4*
Ward, Joseph B., 6912 Fifty-sixth Avenue, South, Seattle 18, Washington *20M-4*
Ward, Robert G., 393 English Road, Rochester 16, New York *44A-2*
Ward, Wayne R., 2256 Orville, Kansas City 2, Kansas *92A-2*
Wardell, Albert W., Box 217, Long Valley, New Jersey *61A-2*
Wardell, Kenneth E., 3183 Prospect Avenue, Riverside, California *78A-2*
Wargo, Joseph B., 1916 Creek Hill Road, R.D. 5, Lancaster, Pennsylvania *71A-2*
Warne, Robert M., 551 Tulane, Saginaw, Michigan *98A-2*
Warner, Anthony F., 11703 Charles Road, Silver Spring, Maryland *14A-2*
Warr, Maxie E., Jr., 7709 East Thirty-first Street, Tulsa 5, Oklahoma *15A-1*
Warrell, J. E., Box 432, Carlisle, Pennsylvania *72M-4*
Warren, James M., 572½ Seventh Avenue, Salt Lake City 3, Utah *50A-2*
Warren, Joseph, 1803 Eileen, Ypsilanti, Michigan *0A-1*
Warren, Victor R., 11402 Robson, Detroit 27, Michigan *47A-2*
Warren, Ward E., R.D. 2, Crestline, Ohio *0M-3*
Warriner, Robert P., The William Carter Company, 33 Morrie Street, Springfield 5, Massachusetts *94M-4*
Warschauer, James E., 198 East Blake Avenue, Columbus 2, Ohio *1A-2*
Warschauer, Thomas Myer, 2306 Fairway Drive, Mobile, Alabama *79M-4*
Warsinsky, Albert E., Sterling Faucet Company, Morgantown, West Virginia *0A-1*
Washauer, Louis H., 800 Kingsland Avenue, University City 5, Missouri *16A-2*
Washburn, Martin W., Jr., 9063 East Arcadia Avenue, San Gabriel, California *23AF-3*
Washer, Richard B., R.D. 1, Box 454, Miller Road, Utica, New York *85A-2*
Wason, Charles P., 1614 Marilyn Avenue, Dayton 20, Ohio *2A-2*
Wassel, George, 1455 East One Hundred Eighty-fifth, Cleveland 10, Ohio *7M-4*
Wasserman, Arnold, 7631 Sagamore, Cincinnati 36, Ohio *39A-2*
Waterbury, J. J., 1026 South Frederick Street, Apartment C44, Arlington, Virginia *14A-2*
Waters, Clyde O., 2900 Dawn Avenue, Odessa, Texas *0A-1*
Waters, Eugene U., 1130 Stuart Boulevard, N.E., Massillon, Ohio *19M-3*
Watkins, Vancil W., 311 North Brazos Street, Weatherford, Texas *0A-1*
Watkins, William L., Eastern Avenue, City #6, Morristown, Tennessee *17A-1*
Watmough, John W., Cerro de Pasco Corporation, La Oroya, Peru, South America *0AF-3*
Watson, Edwin C., Hart Hill Acres, Clark Mills Road, Whitesboro, New York *85M-4*
Watson, George C., 261 Collfield Avenue, Staten Island 14, New York *5A-2*
Watson, Hayward B., 3822 Montevista Road, Cleveland Heights 21, Ohio *7AF-4*
Watson, Jerry, Thiokol, Box 524, Brigham City, Utah *50M-4*
Watson, Lawrence D., 142-10 Hoover Avenue, Jamaica 35, New York *5A-2*
Watson, Robert E., 73 East Riverglen Drive, Worthington, Ohio *1A-4*
Watson, Thomas E., 245 North West End Avenue, Lancaster, Pennsylvania *71A-2*
Watson, Wayne C., Biwood Road, R.D. 1, Ambler, Pennsylvania *31A-2*
Watt, Dale H., 528 East Fifth, Tulsa 10, Oklahoma *15M-3*
Watt, William L., 502 Arbutus Avenue, Seaford, Delaware *0A-1*
Watters, Ralph N., 319 Marlow Drive, Oakland 5, California *12M-4*
Watters, James D., Moore Business Forms, Incorporated, 800 South Raymond, Fullerton, California *23A-1*
Wattleworth, Frank, 815 South Eight Hundred West, Orem, Utah *50A-2*
Watts, Douglas T., 2736 Melinda Drive, Winston-Salem, North Carolina *21M-4*
Wavell, John C., 142 Ballard Drive, San Antonio, Texas *39A-2*
Wayne, S. LeRoy, 4009 Avera Avenue, Winston-Salem, North Carolina *21A-2*
Weakley, Leonard A., Jr., 409 Jade Cove Way, Seal Beach, California *23A-1*
Weaver, Arthur B., 401 East Church Street, Blackwood, New Jersey *31A-2*
Weaver, Earl B., 228 Sarvis Drive, Knoxville 20, Tennessee *11M-4*
Weaver, Frederick C., 28 Strathmore Circle, Rochester 9, New York *44A-2*
Weaver, William H., East Pleasant Street, R.F.D. 3, Amherst, Massachusetts *68M-3*
Webb, Edward T., 815 Rimpau Boulevard, Los Angeles 5, California *23A-1*
Webb, Kenneth B., 3003 Pope Drive, Chattanooga 4, Tennessee *54A-2*
Webb, William T., Malesus, Tennessee *83A-2*
Webber, John A., 516 Harrison Avenue, Greensburg, Pennsylvania *3A-1*
Webber, Robert M., III, 405 Washington Street, Dedham, Massachusetts *30A-2*
Weber, Henry H., 1136 Fernwood Drive, Millbrae, California *37A-1*
Weber, John M., R.D. 1, Renfrew, Pennsylvania *0A-1*
Weber, J. R., 450 South Canal Street, Canal Fulton, Ohio *52A-2*
Weber, Karl Edward, 10 Ellicott Boulevard, R.D. 1, Tanawanda, New York *49M-3*
Weber, Paul B., 409 Apple Road, Newark, Delaware *100A-1*
Weber, Rodolfo A., Altavista 137, San Angel Inn, Mexico 20, D. F. *0A-1*
Webster, Fred E., 408 Guntersville Road, Arab, Alabama *69A-2*
Webster, John F., P.O. Box 1795, Louisville 4, Kentucky *18A-3*
Webster, Robert H., 7827 East Eighth Street, Downey, California *23M-4*
Weeks, H. Wayne, 3025 North West Seventy-first Street, Oklahoma City, Oklahoma *57M-4*
Wefler, Warren H., R.F.D. 1, Massillon, Ohio *19M-3*
Weger, John J., 1236 Canterbury Drive, South Bend 28, Indiana *0A-1*
Wehby, La Vern J., 1332 San Mateo, S.E., Apartment 17, Albuquerque, New Mexico *59M-3*
Wehman, Charles P., 3926 Forest Highland Drive, Chattanooga 5, Tennessee *54A-2*
Wehmer, William C., 221 Willard, S.E., Warren, Ohio *3A-1*
Wehrle, George W., Jr., Industrial Engineering Supervisor, Facilities Planning, Westinghouse Electric Corporation, Sharon, Pennsylvania *24M-3*
Wei, Ignatius Z. S., Acme Industrial Company, 200 North Laflin, Chicago 7, Illinois *25AF-3*
Weichsel, Morton E., The Colorado Fuel and Iron Corporation, 361 Delaware Avenue, Buffalo 2, New York *49M-3*
Weidman, Robert S., 2750 Spring Garden Road, Winston-Salem, North Carolina *21M-4*
Weigel, Richard C., 912 Main Street, Watsontown, Pennsylvania *89A-2*
Weigold, Calvin, R.D. 1, Malvern, Pennsylvania *31A-2*
Weikel, William F., 975 Cardinal Drive, Evansville 11, Indiana *88M-4*
Weil, Kurt, 10702 Shaker Boulevard, Cleveland 4, Ohio *7M-4*
Weil, Lisa, 6615 Deancroft Road, Baltimore 9, Maryland *42M-4*
Weiler, Norman E., 115 Newburgh Avenue, Buffalo 11, New York *49M-3*
Weilnau, Marvin A., 201 West Bogart Road, Sandusky, Ohio *0A-1*
Weinberg, Richard R., 3515 Upper Oakwood Avenue, Elmira Heights 19, New York *48A-1*
Weindling, Joachim I., 71-46 Parsons Boulevard, Flushing 65, New York *5M-4*
Weiner, Leonard, 2869 Bainbridge Avenue, Bronx 58, New York *5A-2*

Weingarden, Marshall L., 73-64 One Hundred Ninety-sixth Street, Flushing 66, New York *5A-4*

Weinrich, Norbert G., 1205 Fairway Drive, Alton, Illinois *16A-2*

Weinstein, Jean P., Assistant to General Manager, John W. Leavitt Company, 195 State Street, Boston 9, Massachusetts *30AF-4*

Weintraub, Donald H., 102-45 Sixty-second Road, Forest Hills 75, Long Island, New York *5A-2*

Weintraub, Emanuel H., 220-44 Seventy-fifth Avenue, Bayside, Long Island, New York *5M-4*

Weinwurm, Ernest H., 25 East Jackson Boulevard, Chicago 4, Illinois *25AF-3*

Weinzimer, Donald H., 1820 Fifty-fifth Street, Brooklyn 4, New York *5AF-4*

Weir, James F., 5817 Eighty-fourth Avenue, Hyattsville, Maryland *14A-2*

Weisberger, Joshua H., 1329 Fifty-third Street, Brooklyn 19, New York *5A-2*

Weisend, Jack R., 10899 South Prospect, Chicago 43, Illinois *25M-4*

Weisent, William A., 366 North Selby Boulevard, Worthington, Ohio *1AF-4*

Weiss, Henry G., Modern Materials Handling, 795 Boylston Street, Boston 16, Massachusetts *30AF-4*

Weiss, Paul E., 9 Dee Court, Hicksville, Long Island, New York *5A-2*

Weiss, Robert H., 38 Windmill Lane, New City, New York *0A-1*

Weissberg, Howard L., 137-21 Eighty-third Avenue, Kew Gardens 35, New York *86A-2*

Weissburg, Allan A., 1210 Roosevelt Drive, Fort Wayne, Indiana *34A-1*

Weissenberg, Peter, 828 Fairfax Road, Drexel Hill, Pennsylvania *31A-2*

Weissman, Michael A., 175 West Seventy-ninth Street, New York 24, New York *5A-2*

Weitz, Harold, 535 West One Hundred Tenth Street, New York 25, New York *5A-2*

Weizenecker, Alex B., 355 South Twenty-first Street, Sebring, Ohio *24A-1*

Welch, Gerard J., Box 157, Balboa, Canal Zone *0A-1*

Welch, Ralph A., 2577 Northwest Boulevard, Columbus 21, Ohio *1A-4*

Welch, Thomas H. E., c/o Line Material Industry, 1700 Vanderbilt Road, Birmingham 2, Alabama *9A-4*

Wellman, Paul I., Jr., 3110 Butler Avenue, Los Angeles 66, California *23A-1*

Wellman, Walter R., Jones and Laughlin Steel Corporation, 8806 Crane Avenue, Cleveland 5, Ohio *7A-2*

Wells, Don, Box 502, Hawkins, Texas *60A-2*

Wells, Robert H., President, Wells and Associates, 185 Montclair Avenue, Montclair, New Jersey *5M-4*

Wells, Roger H., 3835 South Logan, Englewood, Colorado *32A-1*

Welsch, Donald E., 65 Poland Village Boulevard, Poland 14, Ohio *24A-1*

Welsh, William J., 3733 Glen Meade Road, Louisville 18, Kentucky *18A-3*

Welsher, Donald R., 1006 Gerard Avenue, New York 52, New York *5A-2*

Welter, Miles B., 2425 Bradway Boulevard, Birmingham, Michigan *47A-2*

Wemple, Horace R., Jr., Universal Atlas Cement Company, 100 Park Avenue, New York 17, New York *5M-4*

Wemyss, Albert P., Jr., Hawthorne Drive, R.R. 2, Brevard, North Carolina *83A-2*

Wendel, George D., 1220 Jackson Boulevard, Apartment 10, Houston 6, Texas *22A-1*

Wendt, Chester F., 308 Bellemonte Street, Middletown, Ohio *2M-4*

Wendt, Herbert S., Long Island Lighting Company, 175 Old Country Road, Hicksville, New York *86M-4*

Wendt, Willard L., Milford, New Jersey *77M-4*

Wenger, Robert, Ace Electric Service Company, Incorporated, 129 North Third Street, Philadelphia 6, Pennsylvania *31A-4*

Wernecke, Robert B., University of Wisconsin, Mechanical Engineering Department, Madison 6, Wisconsin *45M-4*

Werner, Charles A., 520 Kingsland Avenue, University City 5, Missouri *16A-2*

Wernert, John R., 2412 Cloverdale Road, Donelson, Tennessee *64A-3*

Wertheim, John M., 2840 Sedgwick Avenue, New York 68, New York *5A-2*

Wesemann, Carl L., R.F.D. 1, Rhineland, Missouri *0A-1*

Wessel, Peter, 6772 Hollywood Boulevard, Los Angeles 28, California *23A-1*

Wessman, Eric J., 23339 Westchester Drive, North Olmsted, Ohio *7A-2*

Wesson, Robert W., Union Carbide Chemical Company, Textile Fibers Department, 100 East Forty-second Street, New York, New York *86M-4*

West, James C., 5413 Naples Drive, Dayton 24, Ohio *2A-2*

West, John D., 314 West Springvalley Road, Centerville, Ohio *2AF-4*

West, Leroy H., 1275 East Two Hundred South, Pleasant Grove, Utah *50M-4*

West, Otis C., 4401 West Liberty, Oklahoma City 7, Oklahoma *57A-2*

West, Robert A., 986 Maple Street, Ogden, Utah *50A-2*

West, William L., 2312 Dog River Drive, North, Mobile, Alabama *79AF-4*

Westberg, Frederick T., 913 Third Street, Whittier, California *23M-4*

Westbrook, Maxwell F., 315 North Quincy Street., Apartment 4, Arlington 3, Virginia *14M-4*

Westbrook, R. L., Sr., 6010 Belmont Avenue, Cincinnati 24, Ohio *8A-4*

Wester, Robert E., 1547 East Boulevard, Cleveland 6, Ohio *7M-4*

Westerman, William L., 515 Kaldy Drive, Cincinnati 44, Ohio *8A-2*

Westfall, Emmett M., R.R. 1, Horseheads, New York *48AF-3*

Westfall, Peg, 444 Woodward Avenue, Buffalo, New York *49A-1*

Weston, Austin, 623 North Street, Racine, Wisconsin *45A-2*

Weston, Frank L., 10721 South Morgan Street, Chicago 43, Illinois *25M-4*

Wethington, Thomas D., 120 Ocla Street, Borger, Texas *0A-1*

Wexler, Paul L., Apartment 1, 2046 Snowhill Drive, Cincinnati 37, Ohio *8A-2*

Whalen, John J., 408 West Terrace Street, Altadena, California *23A-1*

Wheatley, Thomas V., P.O. Box 884, Pomona, California *78A-2*

Wheaton, H. O., Jr., American Steel Foundries, 1001 East Broadway, Alliance, Ohio *19M-3*

Wheeler, Donald L., Robertshaw-Fulton Controls Company, Grayson Controls Division, Long Beach 5, California *23M-4*

Wheeler, Dwight E., Box 134, Milford, New Jersey *77M-4*

Wheeler, Iven H., Jr., Minneapolis-Honeywell Regulator Company, 13350 United State Highway 19, St. Petersburg 33, Florida *91A-2*

Wheeler, John D., 5143 Reeds Road, Mission, Kansas *92AF-4*

Wheeler, Michael J., 41 King Avenue, Columbus 1, Ohio *0AF-6*

Wheeler, William C., 17 Rykert Crescent, Toronto 17, Ontario, Canada *87A-1*

Wheeler, William G., 2625 Wheeler Avenue, St. Paul 13, Minnesota *38A-2*

Whetstone, Joseph M., 1523 Azalea, Arlington, Texas *10A-3*

Whish, Arthur M., 195 Upland Road, Quincy 69, Massachusetts *30A-2*

Whisler, Wilton M., 121 South One Hundred Sixty-eighth, Seattle 88, Washington *20A-2*

Whitaker, Wilson C., 2335 Lyon Street, Raleigh, North Carolina *66A-1*

White, Cameron W., Jr., 6261 Third Avenue, North, St. Petersburg, Florida *91A-2*

White, Edwin P., 39 Schuyler Street, Roxbury 21, Massachusetts *30A-4*

White, James H., 130 Cabot Street, San Antonio 1, Texas *39A-2*

White, Kendall C., 37700 Chagrin Boulevard, Chagrin Falls, Ohio *7M-4*

White, Leon S., 18705 Brickell Way, Castro Valley, California *12A-2*

White, Ralph P., B. F. Goodrich Sponge Products, Canal Street, Shelton, Connecticut *97M-4*

White, Thomas B., 12504 Gruss Avenue, Cleveland 8, Ohio *7M-4*

White, Thomas V., 4104 Spruce, Apartment 3, Philadelphia 4, Pennsylvania *31A-2*

White, Walter J., 35 August Avenue, Toronto 13, Canada *87A-1*

White, William B., 2150 Twenty-third Avenue, North, St. Petersburg 13, Florida *91A-2*

White, William E., 424 Cressent Lane, Vestal, New York *96A-1*

White, William H., 2479 A and M Avenue, San Angelo, Texas *0A-1*

Whited, Lyle N., 155 West San Ysidro Boulevard, San Ysidro, California *29A-1*

Whited, Robert L., 6461 Regent, Oakland 9, California *12A-2*

Whitehead, Edwin, 467 Thirty-seventh Street, Oakland 9, California *12A-4*

Whitehead, Richard H., Scott and Williams, Incorporated, 266 Union Avenue, Laconia, New Hampshire *63M-3*

Whitehead, William V., Canadian Pratt and Whitney, Aircraft Company Limited, Manufacturing Division, P.O. Box 39, Longueuil, Quebec, Canada *0A-1*

Whitehead, John G., 657 South Westfield Street, Agawam, Massachusetts *94A-2*

Whitehouse, Richard Z., 1224 Twenty-fourth Street, N.W., Canton 9, Ohio *19A-1*

Whitelow, Alfred A., 145 Martiny Omar, San Isidro, Buenos Aires, Argentina *0M-3*

Whitfield, A. J., 1005 West Thirty-fifth Avenue, Gary, Indiana *53A-1*

Whitlow, George S., Jr., 1212 Manchester Avenue, Norfolk, Virginia *99A-2*

Whitmarsh, James A., Jr., 5236 Lanai Street, Long Beach 8, California *23A-1*

Whitner, Robert E., 1832 Whitehall Street, Allentown, Pennsylvania *77A-2*

Whitney, Ivan H., R.F.D. 1, Mount Morris, New York *44A-2*

Whitney, Lawrence R., 8243 Southeast Twenty-sixth, Mercer Island, Washington *20M-4*

Whitson, Lee S., Toro Manufacturing Corporation, 3042 Snelling Avenue, Minneapolis 6, Minnesota *38M-4*

Whitston, C. Wilson, 2400 Glen Canyon Road, Altadena, California *23M-4*

Whitt, Eugene P., Jr., 303 East Elmira, San Antonio 2, Texas *39AF-4*

Whitt, Fred I., 16 Danbury S.W., Apartment 3, Washington 24, District of Columbia *14A-2*

Whitt, Sidney A., 1004 South Willson, Bozeman, Montana *0M-3*

Whittaker, Charles B., 2464 Bradford Drive, York, Pennsylvania *72A-2*

Wiberg, Harold E., United States Rubber Company, 5675 Telegraph Road, Los Angeles, California *23M-4*

Wichie, Dorr J., R.D. 1, Pine City, New York *48A-1*

Wicker, Homer F., Jr., 708 Dumont Drive, Richardson, Texas *10A-1*

Wickham, William, 9419 Yorktown Drive, St. Louis, Missouri *16A-2*

Wicks, Charles S., 346 Calvert Avenue, Webster Groves 19, Missouri *16M-4*

Wickstrom, LeRoy A., 1443 North Hudson Avenue, Chicago 10, Illinois *25A-1*

Widener, Jackson Ky., Jr., 2029 Wrightsboro Road, Augusta, Georgia *0A-1*

Widmaier, Charles K., III, 3502 Apartment 2, Seventh Street, S.E., Washington 20, District of Columbia *14A-2*

Widoff, Stewart G., 11822 Cherry Avenue, Inglewood 2, California *23A-1*

Wiedemer, Jack, The Gibson Art Company, 2100 Section Road, Cincinnati 27, Ohio *8M-4*

Wiegmann, Francis L., 8221 Laurel Drive, Baltimore 14, Maryland *42A-2*

Wieland, Robert A., Jr., 725 King Avenue, Marion, Ohio *0M-3*

Wiese, James A., 423 Van Roen Road, Utica, New York *85A-2*

Wiese, John M., 880 Lawn Court, Kirkwood 22, Missouri *16A-2*

Wiesehuegel, Richard E., 1421 Alvin Avenue, Williamsport, Pennsylvania *89A-2*

Wiesenfeld, W. Warren, P.O. Box 216, Livermore, California *12A-2*

Wightman, Lester C., Technical Advisor, Hoener Boxes, Incorporated, 600 Morgan Street, Keokuk, Iowa *0M-3*

Wilbert, Robert E., Eaton Manufacturing Corporation, 739 East One Hundred Fortieth Street, Cleveland 10, Ohio *7A-2*

Wilburn, Quentin S., 1366 West Erie, Lorain, Ohio *7A-4*

Wilcox, John D., 1515 Washington Street, Muscatine, Iowa *46A-2*

Wildensten, Charles K., 462 Kentucky Avenue, Berkeley 7, California *12M-4*

Wilder, Guy E., 1120 South Fourth Street, Atchison, Kansas *92M-4*

Wilding-White, Charles F. B., Rensselaer Polytechnic Institute, Troy, New York *0M-3*

Wildman, Sylvan R., Chairman, Standardization, Ordnance Weapons Command Headquarters, Rock Island, Illinois *46M-4*

Wiles, Herman L., Jr., Manager, Metal and Standard Electron Tube Division, Hughes Aircraft Company, International Airport Street, P.O. Box 90427, Los Angeles 45, California *23M-4*

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Wilgus, E. Charles, 6229 Ravenswood Drive, Fort Worth 12, Texas *10A-1*

Wilhelm, George M., Lumber Division Engineer, Boise Cascade Corporation, 13 East Alder Street, Walla Walla, Washington *0A-1*

Wilhelm, George M., Lumber Division Engineer, Boise Cascade Corporation, 113 East Alder Street, Walla Wala, Washington *0A-1*

Wilhide, Warren E., 4406 Kathland Avenue, Baltimore 7, Maryland *42A-2*

Wilhoite, Richard N., Mueller Company, 2501 Chestnut Street, Chattanooga 1, Tennessee *54A-2*

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Wilkes, J. Wray, Department of Industrial Engineering, University of Arkansas, Fayetteville, Arkansas *84A-1*

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Wilkerson, Harold W., 3936 Florac Avenue, LaVerne, California *78A-2*

Wilkie, George S., 518 Verna Drive, Johnson City, New York *96A-1*

Wilkie, James H., Box 452, Brevard, North Carolina *83A-2*

Wilkie, Thomas R., Jr., 962 Watauga Street, Kingsport, Tennessee *17A-1*

Wilkinson, Harry, North Electric Company, 553 South Market, Galion, Ohio *1M-4*

Will, Francis C., 1558 Douglas Road, Wickliffe, Ohio *7AF-4*

Will, George H., R.D. 1, Sayre, Pennsylvania *48A-1*

Willett, Alfred N., Ware Point Road, West Brookfield, Massachusetts *94M-4*

Williams, Alfred S., Sr., 2521 Farnell Drive, Mobile, Alabama *79A-2*

Williams, Bobby F., 601½ Fairview Avenue, Kingsport, Tennessee *17A-1*

Williams, Charles F., 30 Oregon Avenue, Newark, Ohio *1AF-4*

Williams, Donnie J., 3 Poplar Street, Rome, Georgia *93A-2*

Williams, E. D., 1141 Nome Street, Denver 8, Colorado *32M-3*

Williams, Earl L., 624 Broadview Street, Anaheim, California *23A-1*

Williams, Eugene L., Jr., General Telegraph Company of Florida, P.O. Box 11328, St. Petersburg 33, Florida *91A-2*

Williams, Frank H., 11139 East Rineon Drive, Whittier, California *23M-4*

Williams, Franklin T., 1521 West Philadelphia Street, York, Pennsylvania *72AF-4*

Williams, G. Bretnell, 531 Kimberley, Birmingham, Michigan *47A-2*

Williams, Henry R., P.O. Box 401, Old Fort, North Carolina *83AF-4*

Williams, Herbert H., 189 Hurley Avenue, Apartment 8, Kingston, New York *76A-2*

Williams, Jack C., Vickers, Incorporated, 1801 North Eleventh Street, Omaha, Nebraska *90A-2*
Williams, James A., Wyandotte Chemical Corporation, 1609 Biddle Avenue, Wyandotte, Michigan *47A-2*
Williams, James I., 11725 Darlington Avenue, Apartment 2, Los Angeles 49, California *23A-1*
Williams, John R., 3512 Imperial Way, Sacramento 20, California *43A-2*
Williams, Lester R., 425 Eastwood Drive, Fort Worth 7, Texas *10A-1*
Williams, Loren T., 4661 Driftwood Court, El Sobrante, California *12A-2*
Williams, Norman C., 25 Robinson Drive, Port Arthur, Ontario, Canada *87A-1*
Williams, Paul F., 3515 Massachusetts Street, Seattle 44, Washington *20A-2*
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91. Florida West Coast
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